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CHARACTERIZATION OF THE OFF-ROAD EQUIPMENT POPULATION

ARB Contract No. 04-315

Final Report

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Abstract

Off-road equipment is a major contributor to pollution levels in California, generating ozone precursors, particulate matter, toxics, and carbon dioxide. These equipment are found in a wide variety of applications, including lawnmowers, bulldozers, aircraft support equipment, and portable generators, among other categories. Off-road equipment is used in essentially all types of businesses, as well as in residential applications. Given the large number of engines involved, and the highly diverse set of operators, off-road engines have proven more difficult to characterize and control than many other emission categories.

In order to develop a more comprehensive and consistent data set of engine characteristics and activity, ARB contracted with Eastern Research Group (ERG) to conduct a study of off-road engines less than 175 horsepower operating in the state. The study was conducted in two phases, with equipment operator surveys and equipment instrumentation techniques developed and tested under Phase I, and full scale data collection and analysis taking place under Phase II. The study results include detailed information on equipment characteristics and activity, including application type, horsepower, and hours per year of use. Surrogates were developed to extrapolate the survey data to statewide totals, as well as to allocate equipment populations to the county level. Instrumentation of data loggers was also performed to collect engine-on time, in-use RPM and exhaust gas temperature data for different types of construction equipment. Based on the study findings, recommendations are provided for updating the current OFFROAD emission factor model, as well as the list of federally preempted off-road equipment in California.

Executive Summary

Background

Off-road internal combustion engines are significant contributors to fine particulate matter, air toxics, and ozone precursor emission inventories in California. Their widespread use across many applications requires they receive detailed assessment for both emissions inventory improvement and potential regulatory development in California. The study described in this report was implemented to develop a comprehensive and consistent profile of off-road equipment applications, end-users, populations, and activity patterns for equipment less than 175 horsepower (hp), for the range of different equipment operators across California. The resulting equipment inventory and instrumentation data can be used to: improve current off-road equipment counts and emission inventory estimates; determine if the current list of preempted off-road equipment should be updated; and obtain in-use equipment activity data to help identify equipment types that may be amenable to various control strategy options.

Methods

The study was conducted in two phases, with Phase I involving a small-scale pilot test of the data collection effort. The Phase II study (the subject of this report) implemented the survey and equipment instrumentation methodology developed under Phase I as a full-scale data collection effort. Data collection relied on self-reported information from a representative sample of off-road equipment operators across the state, using questionnaires administered by phone. Working closely with ARB and key stakeholders, the survey study design was developed by identifying the businesses and residences to be included in the study, the equipment types, and the data elements to be collected (e.g., fuel type, annual hours of operation, hp, and how the equipment is used, among others). After completion, survey responses were quality assured, and the equipment population and activity estimates extrapolated to the state level. The effectiveness of the survey was evaluated in terms of the level of uncertainty associated with the final fleet estimates, such as average hp and average hours per year.

In a parallel task construction equipment were selected for data logger instrumentation to collect temporal operation profiles, engine RPM, and exhaust gas temperature. Loggers were installed on each unit for one week. These data provide daily hours of use as well as inferred operation mode (idle versus load) for different equipment types and applications. Such data may be used to help establish operational profiles for emissions estimation and/or control assessments.

Results

The equipment operator survey provided an extensive data set for various off-road equipment/fuel type combinations, including a number of different equipment characteristic and operation parameters. Factors were identified and applied to the reported equipment counts to develop statewide equipment population and activity profiles. An error analysis of the profiles found the confidence levels for average hp and average hours of operation were relatively precise for several key equipment categories. Although equipment population estimates had significantly greater uncertainty, reasonably accurate population, hp, and activity estimates were obtained for diesel agricultural tractors, compressed gas industrial forklifts, and assorted

residential lawn and garden equipment. Activity and hp data may also be utilized for other equipment categories.

OFFROAD model year distributions may be updated for some of the most common equipment such as agricultural tractors and compressed gas industrial forklifts. The age distribution for agricultural tractors was heavily weighted toward older units, with the median age more than 20 years old. Fuel type distributions could also provide useful model updates, particularly for diesel all terrain vehicles (ATVs), which are not listed in the current model, and for gasoline agricultural tractors, which were much more prevalent than assumed. Seasonality data indicate a substantial variation in activity levels over the year among agricultural, recreational, and lawn and garden equipment, and could provide a basis for updating the seasonal allocation factors within the model. Geographic allocation factors were also developed for the distribution of statewide populations to the county level.

Comparison of the study's equipment population estimates with independent data sources indicates a systematic under-reporting of many construction and recreational equipment types. In addition, several specialty equipment categories were identified by a very low number of respondents, or not at all by the survey. More notable examples include: airport GSE, rough terrain forklifts, and TRU. In addition, certain end-user groups appear to be under-represented, namely commercial lawn and garden companies and public sector fleets. As such, alternative data sources are likely needed for these equipment types and end users.

Uncertainty associated with both equipment populations and activity levels make preemption determinations difficult for the different equipment categories. While most activity distributions appear consistent with ARB's current preemption list, a few exceptions were identified. ATVs merit particular evaluation to determine if they should be included with agricultural equipment.

Engine RPM and exhaust gas temperature data were collected on over 70 pieces of construction equipment. Equipment types included backhoes, loaders, and excavators in both public and private operation. Engine on-time covered a broad range, from a few hours per week, to heavy use five or more days per week. Exhaust gas temperature profiles were also highly variable, even within the same equipment category. Accordingly, generalizations about operation time and exhaust gas temperature distributions could not be made regarding the construction fleet in California, or even regarding the specific equipment types instrumented for this survey.

Conclusions

The equipment operator survey successfully collected extensive information on the targeted equipment fleet operating in California, including data on populations, fuel type, hp and model year distributions, annual hours of operation, seasonal activity, and user applications. Much of the equipment population and activity data collected may be integrated into ARB's OFFROAD model, thereby improving the state's emissions estimates for off-road sources. Application data may also be used to update ARB's list of preempted off-road equipment less than 175 hp. Engine instrumentation data may also help design future studies to assess retrofit potentials for construction equipment operating across the state. Recommendations for additional research include conducting targeted assessments of construction and recreational equipment using alternative data sources, and further evaluation of ATV uses for preemption determination.

1.0 Introduction

Project Background

Off-road internal combustion engines are significant contributors to the fine particulate matter, air toxics, and ozone precursor emission inventories in California. These sources operate in a broad range of applications for an extremely diverse set of industrial and residential end users, from manufacturing and warehousing companies to recreational boaters. As such, off-road engines have proven more difficult to characterize and regulate than many other emission categories such as on-road mobile and major stationary sources. Nevertheless, their widespread use across so many applications requires they receive detailed assessment for both emissions inventory improvement and potential regulatory development in California.

The California Air Resources Board (ARB) has been at the forefront of emissions inventory and regulatory development in the off-road sector with initiatives such as the Small Off-Road Engine (SORE) rulemaking, and the recently completed residential lawn and garden equipment survey.(1) In addition, in many ways the California OFFROAD emissions model provides more detailed data on a broad range of off-road engine categories than does the U.S. Environmental Protection Agency's (EPA's) NONROAD model.

However, much of the equipment population and activity data used in the latest version of OFFROAD are obtained from a host of different data sources, each with its own advantages and disadvantages. For example, the MacKay and Company and Power Systems Research (PSR) data sets used to compile much of the construction, light commercial, and industrial equipment category information are based on nationwide surveys, allocated to California using varying adjustment factors. On the other hand, while the U.S. Department of Agriculture's (USDA) Agricultural Census data are specific to agricultural equipment in California, the Census does not cover all equipment types in this category. Also, the Portable Equipment Database, which is the basis for certain portable engine information, relies on voluntary registration and therefore underestimates equipment counts to some degree. Finally, for many of these data sources the level of information regarding specific equipment applications and end-users is inadequate for ARB's needs.

Ideally all the source category information used in OFFROAD and ARB's regulatory development efforts would be based on comprehensive, bottom-up survey data from across California. In recent years, ARB has taken steps to initiate this process, including development of an inventory for public sector fleets,(2) the residential and commercial/institutional lawn and garden survey and instrumentation studies, and the survey of Transportation Refrigeration Unit (TRU) vendors,(3) among others. In addition, locality-specific inventory information for other source categories such as aircraft ground support equipment (GSE) is sometimes provided at the air district level, in this case often utilizing the Federal Aviation Administration's (FAA's) Emission Dispersion and Modeling System (EDMS).

In August 2005, Eastern Research Group (ERG) was selected to conduct continuing research into the characteristics of California's off-road equipment fleet. The study was conducted in two phases. Phase I covered the tasks associated with planning and designing the study: defining the equipment types for inclusion, defining the data to be collected on the equipment types,

developing a survey plan, and creating a survey instrument and sample. Phase I also included a small-scale pilot test of data collection and field instrumentation methods to assess their effectiveness and efficiency. Phase I concluded with documentation of all activities through the pilot test, with recommendations on methodology refinements for the full-scale study.

The full-scale, Phase II study began after submittal of the Phase I report and written authorization by ARB. Minor changes to the equipment operator survey and instrumentation procedures were implemented to improve data collection accuracy and efficiency. The study results include detailed information on equipment characteristics and activity, including application type, horsepower, and hours per year of use. Surrogates were developed to extrapolate the survey data to statewide totals, as well as to allocate equipment populations to the county level. Instrumentation of data loggers was also performed to collect engine-on time, in-use RPM and exhaust gas temperature data for different types of construction equipment. Operator surveys were completed in June of 2007, and equipment instrumentation was completed in November of 2007. Data post-processing, quality assurance and statistical analyses were conducted on the resulting data sets. Based on the study findings recommendations were developed for updating the current OFFROAD emission factor model, as well as the list of federally preempted off-road equipment in California.

This report summarizes the methodology and findings of Phase II of the study.

Project Objectives

Through this study, ARB desired to develop a comprehensive and consistent profile of off-road equipment applications, end-users, populations, and activity patterns for the range of different industrial, public, and residential equipment operators across California. The focus was on off-road equipment less than 175 horsepower (hp). Data collection relied on self-reported information from a stratified random sampling of off-road equipment operators across the state, using questionnaires administered by phone. Additional in-use activity data was collected through the deployment and retrieval of data loggers in the field. This approach, utilizing California-specific, "bottom-up" data collection, was assumed to provide a more reliable characterization of equipment types and use patterns than prior "top-down" efforts, which commonly rely on national data combined with regional allocation routines.

The resulting equipment inventory and instrumentation data was developed to serve the following purposes:

- Create and/or use an equipment categorization scheme consistent with ARB's OFFROAD model conventions to facilitate the improvement of the emission inventory and regulatory development;
- Characterize equipment populations in the various categories and types by fuel type, engine size, age, annual hours and seasons of use, and the applications of the equipment;
- Obtain in-use data on equipment activity which can be used by ARB to identify types of equipment that are amenable to various control strategy options;
- Provide equipment counts that can be used to estimate total numbers of the equipment at the state and county levels; and,

- Determine if the current list of preempted off-road equipment should be updated.

Report Organization

The following sections of this report document the study methodology followed for conducting the Phase II data collection, and presents the operator survey and equipment instrumentation results. A discussion of the results, including a statistical analysis and assessment of data set completeness is then presented. A summary of the major findings of the study are presented next, along with recommendations regarding potential updates to the OFFROAD model and the off-road equipment preemption list. Utilization of equipment instrumentation data is also discussed. Finally, recommendations for future refinement of the resulting data set are provided.

2.0 Materials and Methods

Overview

The purpose of the Phase II study was to implement the survey and equipment instrumentation methodology developed under Phase I as a full-scale data collection effort. Working closely with ARB and key stakeholders, the Phase I study design was updated to improve survey response rates and data collection efficiency.

The survey study design was then developed by defining the sample frame (e.g., the commercial businesses and residences to be included in the study), equipment types, and the data elements to be collected. Next steps included designing the corresponding survey instrument to collect the required data elements, as well as other survey materials (e.g., survey instructions and advance letter), and programming the survey questionnaire for data collection via telephone.

The Phase II study data collection effort was conducted from February 23, 2007 through May 25, 2007 using telephone interviewing. In order to obtain missing demographic data in the Residential Sector for weighting purposes, a small additional data collection effort was conducted from June 12, 2007 through July 9, 2007 for residential respondents.

Once complete, survey responses were quality assured and otherwise evaluated for reasonableness. The effectiveness of the survey was also evaluated in terms of overall response rates, non-response for individual questions, and other factors that could bias the results of the full-scale survey.

In addition to the survey effort, a parallel task was undertaken to identify candidates for data logger instrumentation, in order to collect temporal operation profiles, engine RPM, and exhaust gas temperature. During Phase II, data loggers were installed on pieces of construction equipment for a period of one week. These data allow for the estimation of daily hours of use as well as inferred mode (idle versus load) for a range of different equipment types and applications. Such data can be used to help establish detailed operational profiles for emissions estimation and/or control assessments.

The following sections of this report document the data collection methods for the survey as well as the instrumentation tasks.

2.1 Equipment Characterization Survey

2.1.1 Sample Frame Development

At the onset of the survey planning process, three broad categories, or sample frames, were identified to characterize the range of possible off-road equipment operators. Samples of potential equipment operators would then be derived from these three distinct sampling frames:

- *Agricultural frame*, to characterize the agricultural industry, consisting of all farmers and farm management companies in the State of California that report income from the sale of their crops and/or management services;

- *Commercial frame*, consisting of California businesses and public entities. This frame was further disaggregated, using SIC codes, into the following strata for purposes of manageability and subsequent application of surrogates: Construction/Mining, and Other Commercial/Government entities (referred to as the "Residual" sample in this report);
- *Residential frame*, consisting of listed and unlisted non-business telephone exchanges in the state of California.

After consultation with ARB, stakeholder groups, and sample providers, it was determined during Phase I that additional sample stratification would be necessary to collect sufficiently detailed data for the different sectors. Agricultural entities were identified by crop type as reported to the Federal Census Bureau. The following provides a list of the final agricultural sample strata.[1] For a detailed list of all crop types included in each agricultural stratum, please see Appendix A.

- Nut
- Row Crop
- Tree Fruit
- Other
- CAFO/Dairy
- Farm Management[2]

During Phase I study design planning, agricultural stakeholders raised concerns regarding how the survey would capture equipment data from farms with "absentee" owners (farm owners that do not reside on the property in question and use a farm management company for all operations), as well as from farms which contract out some, but not all, of their operations to another local farmer (who is not considered a farm management company). These issues were explored further during the Phase I pilot study through interviews with farmers that provide services to, or receive services from, other farmers in their community. To ensure equipment used in these instances was properly captured, farm management firms were included in the sample frame as a separate category.[3] Further, the questionnaire was designed to capture equipment owned or leased by individuals (i.e., not farm management companies) who provided agricultural services on land owned by other farmers in addition to their own. To collect this information, the questionnaire asked farmers/operators about the equipment they own and operate in California, as opposed to the equipment used specifically on their farm. "Now, this

[1] In order to stratify at this level of detail, the project team used an agricultural database maintained by the US Department of Agriculture (USDA). The sample was purchased through a third party that pays a subscription service for access to the database. The project team received a summary report of crop types grown in California and aggregated them into the categories shown above.

[2] Farm management entities are defined as businesses that perform agricultural activities (such as harvesting, plowing, etc.) for other farmers for a fee, as their primary activity.

[3] Farm management entities were subsequently re-assigned to one of the remaining strata based on their reported activity type for the purposes of surrogate expansion.

next series of questions will focus only on the equipment contained in your current inventory of owned or leased equipment that operates in California" [from telephone interview script].[4]

Agricultural sample frames were subsequently developed using existing databases maintained by the following commercial sources.

- For non-farm management agricultural entities, the sample frame consisted of an agriculture database maintained by the US Department of Agriculture (USDA), subscribed to by Survey Sampling International (SSI), a commercial survey sample vendor. This database contains nationwide coverage for growers of agricultural crops. In addition to administrative data such as name, address and phone number, the database lists the following for each grower: crop type, acreage, and reported annual income from sale of crop.
- For farm management entities, the sample frame was based on the Standard Industrial Classification (SIC) database maintained by Dunn and Bradstreet. The SIC used is a four-digit code that identifies the primary industry sector of which the company is a member.

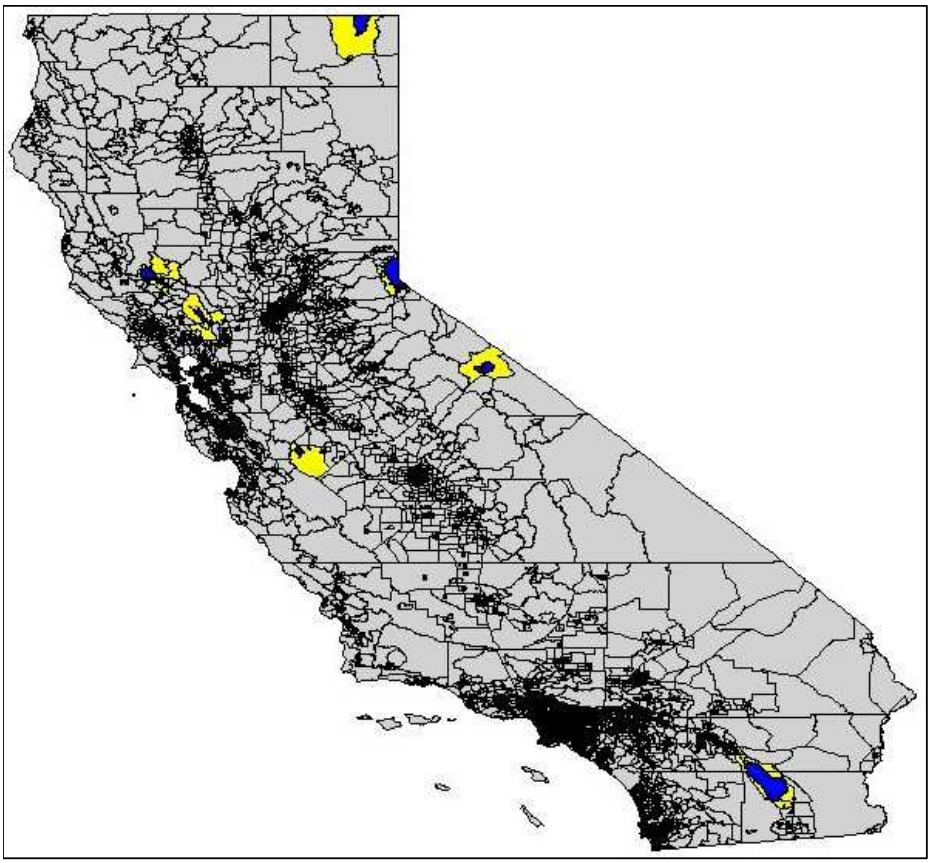
Additional sub-stratification was deemed necessary for the remaining user categories. Mining, logging, and "recreational" sub-strata were defined within the Construction, Residual, and Residential strata, respectively, in order to ensure data collection on specialty equipment types. For further detail on the specific SICs selected for the Agricultural, Construction, and Residual sample frames see Appendix B.

The Residential frame was partitioned into Recreational (or "Target") and Other (or "Non-Target"), with the Recreational sample defined as households that live in close proximity to recreational areas, such as a major lake or national recreational area. After consultation with ARB staff, the following counties were included in the recreational target substratum: El Dorado, Imperial, Lake, Merced, Napa, and Placer. The areas selected as the basis for the Recreational sub-strata are also shown in Figure 1.

Although households located in other areas of the state may travel to the designated Recreational area counties and use their off-road equipment there from time to time, no attempt was made by the survey to characterize the transient movement of equipment to other regions. This was true for other survey sectors as well. Therefore equipment identified through the surveys was assumed to be operated in the county where the associated respondent was located.

[4] One option for collecting information on equipment used on a property but is not owned or leased by the owner/farmer is to obtain a referral of the name of the operator/service provider, and then conduct a subsequent survey with this additional contact. ARB decided against this option for several reasons, including the potential response error resulting from service providers inaccurately reporting annual/seasonal activity data for equipment used on a particular farm, as well as the overall increase in data collection costs to pursue potentially multiple referrals for a single farm.

Figure 1. Location of Recreational Target Sub-Strata



2.1.2 Survey and Sample Size Determination

A total of 1,200 completed surveys were originally planned for the full-scale study. Table 1 presents the goals of the study for the total number of completed interviews, taking into consideration the surveys completed in the Phase I pilot study. The table first presents the original study goals followed by the revised study goals based upon the pilot results. The precision estimates refer to the confidence interval for the total number of completes at the 95% confidence level.

Table 1. Pilot and Full Study Completes By Sample Type and Sub-Strata

Sample Type	Phase I Pilot Completes	Original Full Study			Revised Full Study		
		Full Study	Total Pilot + Full	Precision	Full Study	Total Pilot + Full	Precision
Agriculture	29	271	300	5.8	246	275	6.4
Construction	10	240	250	6.3	215	225	6.7
Residual	12	288	300	5.8	263	275	6.2
Residential	12	348	350	5.3	313	325	5.7
Total	**63**	**1,147**	**1,200**	**2.9**	**1,037**	**1,100**	**3.0**

The total completed surveys were reduced from 1,200 to 1,100 as a result of the response rates in the Phase I pilot study. However, perhaps due to the changes made to the survey procedure based on ARB and stakeholder input, interviewing productivity was higher than anticipated and the revised study goals were exceeded for all Sample Types (see Table 9 for details).

At the onset of a survey study it is generally unknown how many sample records would be required to obtain the target number of survey completions for each strata and sub-strata. "Ineligible" sample can arise for a number of reasons – establishments are no longer in business; they have moved operations out of state; the business was bought out and now is listed under a new owner or name; etc. Moreover, not all establishments will operate off-road equipment. Finally, not all establishments will ultimately cooperate with the study. For these reasons it is important to obtain substantially more sample than the targeted number of completed surveys.

The sample needs estimated for the full study are presented in Table 2. Estimates are based on SIC lists obtained from Dunn and Bradstreet for the State of California, US Census data, past survey experience using listed and unlisted sample, and Phase I survey results including contact and non-contact rates, screening response rates, eligibility and survey completion rates.

Table 2. Estimated Number of Sample Records Needed to Meet Survey Targets

Sample Type	Sub-strata	Minimum Quota	Assumed Completes	Completion Rate	Total Sample
Agriculture	Nut Crop	34	275	3.5%	7,000
	Row Crop	45			
	Tree Fruit	29			
	Other Crop	46			
	CAFO/DAIRY	12			
	Farm Management	7			
Construction	Construction	210	225	2.4%	9,000
	Mining*	5			
Residual	Logging*	5	275	4.0%	6,500
	Other	258			
Residential	Recreational*	75	325	2.7%	11,500
	Other	145			
Total			**1,100**	**3.1%**	**34,000**

*The universe totals for these sub-strata are low and minimum quotas could not be applied to the corresponding sample types.

Completion rates refer to the fraction of all respondents in the sample that are eligible to participate and actually complete the survey. Response rates refer to the fraction of eligible respondents that actually participate in the survey. Surveys are adjusted for low/high response rates using analytic weights, as discussed in Section 3.1.4.

Table 2 also shows target quotas by sample subtype. Setting minimum quotas ensures that the sample is representative of all the sample subtypes. Minimum quotas were set such that they met the following criteria:

- The minimum quotas for each sample subtype should be proportional to the distribution of the count of completes by sample subtypes within a sample type.
- The sum of the minimum quotas by sample subtypes within a sample type should represent 70% of completes required for that sample type. This will ensure that the sample type is well represented within each sample subtype.

When the minimum quota level defined above is reached for each sample subtype, the remaining completes required for the full study could be met by completes from sample subtypes that are easier to obtain. This approach ensured that the sample is well represented within each sample type and within the available budget. In addition, since the actual call lists were developed randomly from within each sample subtype, and since response weights were ultimately used to adjust for non-response bias (see Section 3.1.4), the final weighted data set was also representative of the sample universe as a whole. Maintaining this representativeness in the final data set was a primary goal of the study methodology itself.

This methodology works well for strata that are characterized by robust universe counts such as Agriculture. However, when this methodology is applied to strata with small universe counts (particularly Mining and Logging), the resulting minimum quotas are too small to ensure any type of statistical validity. As such, in lieu of using the same method for establishing minimum quotas for these substrata, a different approach was necessary, as described below.

1) **Construction and Mining Stratum**. This stratum is characterized by one substratum that has a very high universe count (Construction) and one substratum that has a very low universe count (Mining). As such, applying the "minimum quota" methodology would result in a minimum quota of 1 for the Mining substratum, which is not recommended. Rather, known sample performance parameters from the pilot survey and known universe counts were used to identify a quota of 5 completed surveys for the Mining substratum, with the balance coming from the Construction substratum (210).

2) **Residual Stratum**. Similar to Construction and Mining, this stratum is characterized by one substratum that has a very low universe count (Logging) and one substratum that has a very high universe count (Residual). To prevent a very small cell size for the Logging substratum, known sample performance parameters from the pilot survey and known universe counts were used to identify a quota of 5 completed surveys for the Logging substratum, with the balance coming from the Residual substratum (258).

3) **Residential Stratum**. This stratum is fundamentally different from the others since the sampling element is a household, not a commercial establishment. Similar to the method implemented with the Agriculture Stratum, a Residential minimum quota was established for the Residential substratum such that the minimum quota represented 70% of the completes required for that sample type. Upon review of pilot sample performance parameters, it was decided to have one third of the minimum quota come from the Recreational target substratum, with the balance coming from the remainder of the residential substratum.

The generation of SIC-based samples involved providing a list of appropriate SIC codes to SSI for each sample type, as well as the number of requested sample records. Samples were then randomly selected from the SIC database by SSI and delivered electronically for further processing. SSI generated the non-farm management agriculture sample in a similar manner by randomly querying the USDA database until the specified number of records by crop type and farm size had been generated. The files were then delivered electronically.

Upon receipt, the electronic sample was processed for dialing by partitioning the sample into "replicates," or subsamples, of the main sample. Each replicate ranged in size from 67 to 250 sample pieces, with each replicate containing sample of the same sample strata. The database contained non-address related information (except first and last name), phone number and geographic identifier (census tract). The database also contained a unique sample number to link each record between databases and track each record throughout the survey process.

2.1.3 Survey Instrument Design

The survey instrument (or questionnaire) contained approximately 20 questions. The first series of questions establishes eligibility (owning and/or leasing at least one piece of off-road equipment with a maximum horsepower rating of less than 175), then proceeds with the substantive part of the data collection effort. In addition to collecting details on the numbers and types of equipment contained in a respondent's inventory, the survey also asks respondents for the seasonal and annual use of each piece of equipment, as well as details on fuel type, horsepower and displacement, etc. These data fields were selected to be consistent with the key data needs of the OFFROAD model. Information on primary and secondary applications of the equipment was gathered as well, to assess the accuracy of ARB's current off-road equipment preemption list.

Cognitive testing[5] of a draft version of the questionnaire was conducted during Phase I. Minor adjustments to question wording and flow were made based on the cognitive test results. In addition, to facilitate respondent completion, the survey instrument was tailored to each specific Sample Type. For instance, example equipment categories were made appropriate for construction, residential, and agricultural respondents.

2.1.4 Updates to Phase I Study Design

Based on the findings of the Phase I study it was determined that the advance letter and mail out/internet version of the survey were not effective in improving response rates, and were withdrawn from the Phase II study design. In addition, a number of edits were made to the questionnaire to improve organization and comprehensibility, including the following:

[5] A cognitive interview is a preliminary test of a draft survey questionnaire with persons that possess similar characteristics to the survey's intended audience, involving in-person interviewing. The testing objectives are related to the question-answering process for potentially complex questions, assessing the respondents' ability to provide an answer by examining their comprehension of questions, and their ability to retrieve relevant information from memory. Cognitive interviews are also used to assess the adequacy of the questionnaire flow (structure and design).

- The screening questions were rearranged and restructured so that eligibility would be established at the onset of the survey;
- The definition of target equipment was refined to read "Off-road Vehicle or Off-road Equipment means any non-stationary device used off the highways and powered by an internal combustion engine or electric motor, including equipment such as portable generators";
- Two questions were deleted because the pilot study revealed that the flagging for large and small inventories was unnecessary. Not a single "large inventory" respondent opted to complete the survey using an alternative survey approach;
- Text was added to prompt respondents to confirm seemingly anomalous equipment application types (e.g., recreational equipment claimed to be used in agricultural activities); and,
- References to "compressed natural gas" were changed to "natural gas".

In addition, based on input from the agricultural stakeholder group nurseries were moved from the Agricultural to the Residual sample frame (see next section), and CAFO/Dairy respondents were asked for the number of head of cattle rather than acreage (to facilitate more accurate surrogate expansion of the results).

A copy of the final survey instrument is provided in Appendix C.

2.2 Equipment Instrumentation

As part of the effort to characterize off-road engine operation, data loggers were to be installed to record selected engine parameters on pieces of equipment operated in the construction and mining sector in California. At the start of the study, ARB determined to limit instrumentations to equipment in the construction and mining sector. This limitation was made in part due to the extremely diverse equipment and application types within the agricultural and residual sectors. In addition, the construction and mining sector is heavily dominated by large diesel equipment, and therefore is a predominant contributor to total nitrogen oxide (NOx) emissions from off-road engines.

In Phase I of this assessment, data loggers were installed on two pieces of construction equipment, one with a mechanically controlled diesel engine, and one with a computer controlled diesel engine, for a period of one week in order to establish instrumentation and data processing protocols. At the request of ARB, ERG modified the Phase I instrumentation protocol to incorporate collection of exhaust gas temperature data in addition to engine on-time and RPM under Phase II for more than 70 pieces of construction equipment. The resulting operation profile can be used to help assess the potential effectiveness of various retrofit options (e.g., diesel particulate filters and diesel oxidation catalysts).

2.2.1 Data Logger Characteristics

During Phase I a data logger made by Clēaire was chosen to log engine parameters. The Clēaire logger was selected because it is normally used to monitor diesel engine parameters, as well as to operate emissions control systems that can be retrofit onto diesel vehicles. Therefore it has many more capabilities than simply recording RPM data. The main parts of the Clēaire logger system

are shown in Figure 2. The gray box contains the logic and memory of the data logger. The various black and blue umbilicals connected to the gray box are used to transmit engine data, emission control system data, and to power the logger. In Phase II three umbilicals were always used, one to transmit the RPM signal to the logger, one to power the logger, and one to transmit exhaust temperature. The unused umbilicals were secured safely out of the way during data logging operations.

Figure 2. Clēaire Data Logger System (Source: Clēaire)

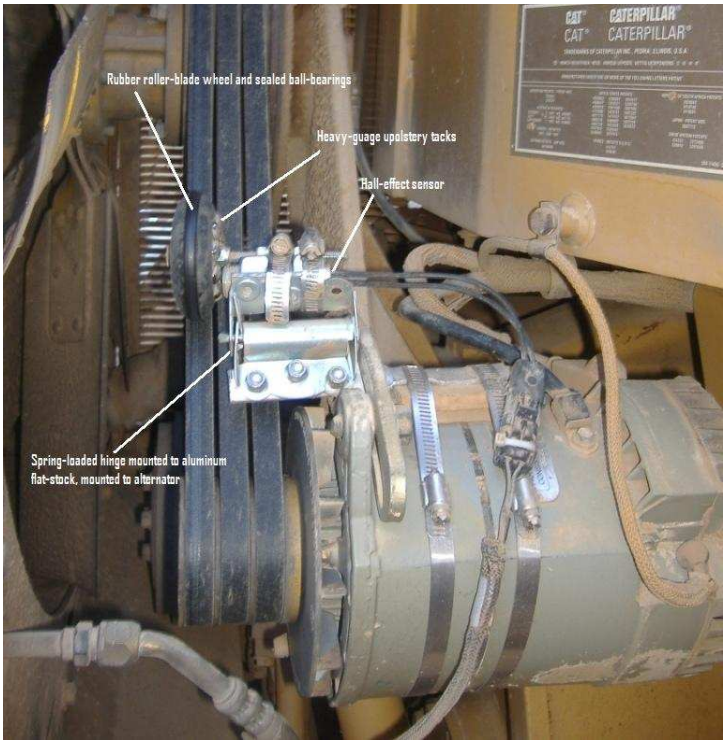
2.2.2 Sensor Installation

RPM was recorded using two methods. The preferred method utilized a Hall-effect sensor installed in the bell-housing of the engine to sense the teeth of the flywheel as they pass the sensor during engine operation (see Figure 3). Since the flywheel is directly connected to the crank-shaft of the engine, its rate of spin is directly proportional to the RPM of the engine. This method required an accessible, threaded port of the proper size in the engine's bell-housing.

Unfortunately, such a port was often not available. Accordingly, a second method of RPM detection used the Hall-effect sensor to determine the rate of spin of an idler pulley on the alternator belt of the engine. Since the alternator belt is driven by the crank-shaft of the engine, its speed is also directly proportional to the RPM of the engine. The idler pulley was fashioned like the rubber wheel of an in-line skate, with shielded ball bearings that come with the wheel, and a bolt (used as a shaft for the pulley). Heavy upholstery tacks were pushed into the rubber wheel in a symmetric pattern to provide the Hall-effect sensor moving metal objects to sense as the wheel rolled on the belt. An installed idler pulley RPM sensor is shown in Figure 4.

Figure 3. Hall-Effect Sensor Installed in Bell-Housing of Engine

Figure 4. Idler Pulley/Hall-Effect Sensor Assembly



RPM was calibrated in the field using the RPM readout and the engineering judgment of the installers (both of whom were mechanical engineers). This method was considered adequate to differentiate between engine idle and loaded modes of operation. A more precise calibration of RPM would have been required in order to fully quantify engine load, however.

Exhaust temperature was typically monitored at the exit of the exhaust pipe. A thermocouple (type K) was inserted into the exhaust stream, approximately 3-inches into the exhaust pipe. The end of the thermocouple was kept from touching the interior of the exhaust pipe by rigidly securing the base of the thermocouple to a spring 'stand-off' on the exterior of the pipe, then bending the thermocouple into a 'U' shape so it extended into the exhaust pipe without touching the interior wall. In some cases, exhaust temperature thermocouples were already installed in the exhaust system (for example, when a particulate filter system had been retrofitted onto the vehicle). In these instances, ERG simply tapped into the existing exhaust thermocouple.

2.2.3 Logger Installation and Removal Procedures

ERG developed a standard procedure to ensure consistent quality of the installation and resulting data. To begin installation, the installer familiarized himself with the vehicle and, if necessary, had an operator demonstrate safe engine starting and stopping procedures. Then the data logger, sensors, and signal and power wires were laid out and loosely attached to temporarily secure them. Then the system was tested to ensure all components were working properly. The calibrated RPM was required to fall between 650 and 850 at idle, and between 1,500 and 3,000 at maximum governed engine speed. The thermocouple reading had to be reasonable when held in ambient conditions, with the exhaust above 200 degrees C at high RPM. After RPM and temperature readings had been quality assured in the field, the installer secured all connections, wires, and the logger and connections safely out of the way of all engine operations and maintenance.

When possible the installer would periodically check active data logging systems already on the engine to determine if any repairs or recalibrations were necessary. In the cases where a logger system failed, ERG would diagnose the problem and re-start the logging. At least one week of logging was required before a system was removed. In those cases where a system had to be removed in less than one week, another piece of equipment was found and the logging process was re-started.

A copy of the field installation and retrieval procedure is provided in Appendix D.

2.2.4 Equipment Sample

ARB specified a list of equipment types for instrumentation during Phase II. This list was based upon a review of previous off-road equipment surveys and internal discussions among ARB staff.(4) The preferred equipment list is shown in Table 3. Three age bins were specified as desirable: 1995 and older, 1996 to 2001, and 2002 and newer, although no specific quotas were established for the different bins.

Table 3. Target Construction Equipment Categories for Instrumentation

Backhoe	Tractor
Loader	Rubber Tired Loader
Excavator	Claw Tractor
Trencher	Roller
Grader (Construction)	Grader (Snow)
Paver	Scraper
Chipper/Stump Grinder	Other*

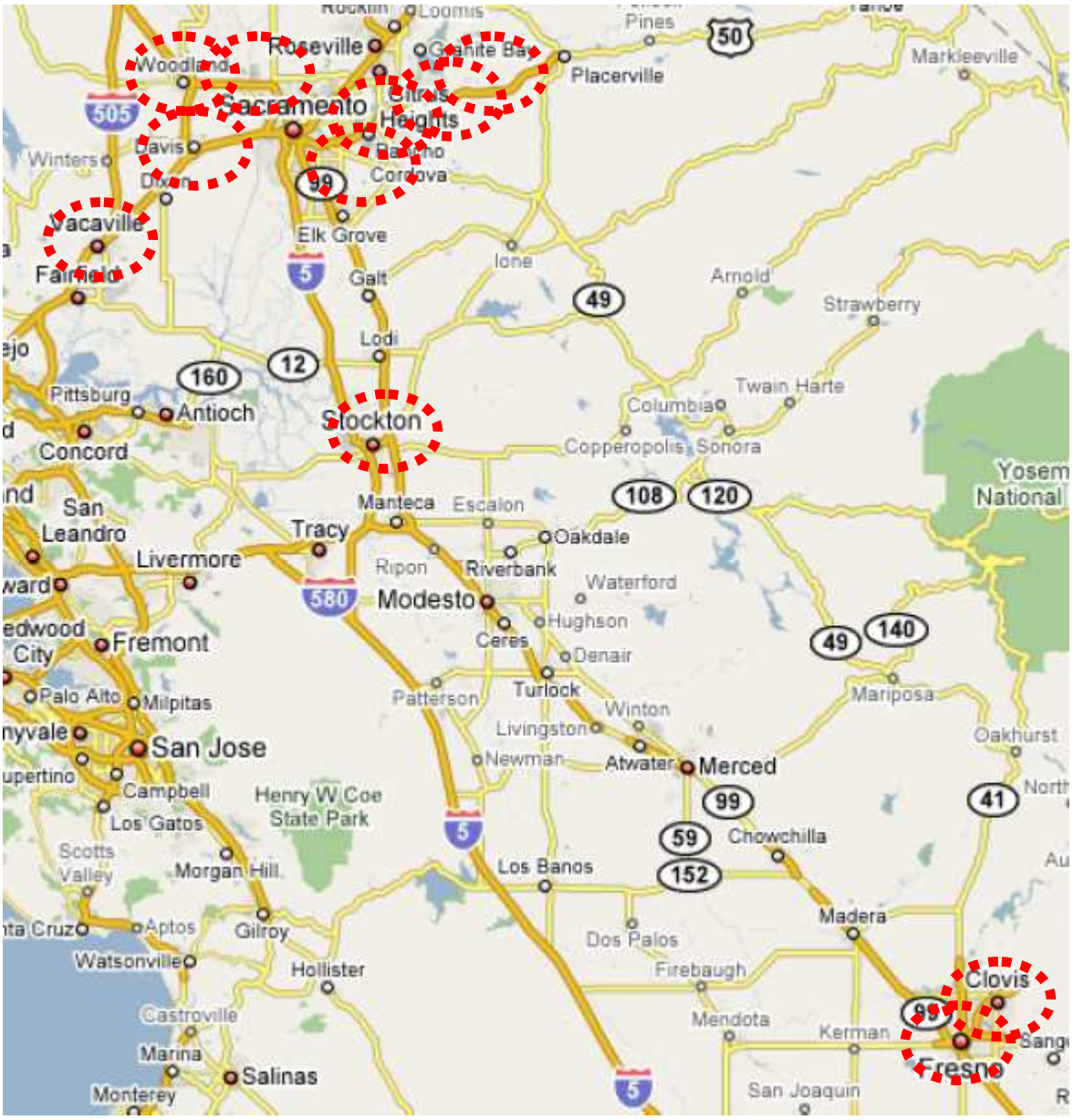
* Based on ARB approval.

ERG negotiated with many fleet owners to identify equipment for instrumentation. With a few notable exceptions, publicly owned fleets tended to be the most cooperative and willing to participate. A list of the publicly owned fleets contacted for this study is shown in Appendix E.

The three private fleets participating in the study were owned by Teichert Construction, Doug Veercamp Construction, and Hobday Equipment Rental. Twelve other private fleet owners were contacted for participation in the study and either did not have equipment needed for the study or were unwilling to participate.

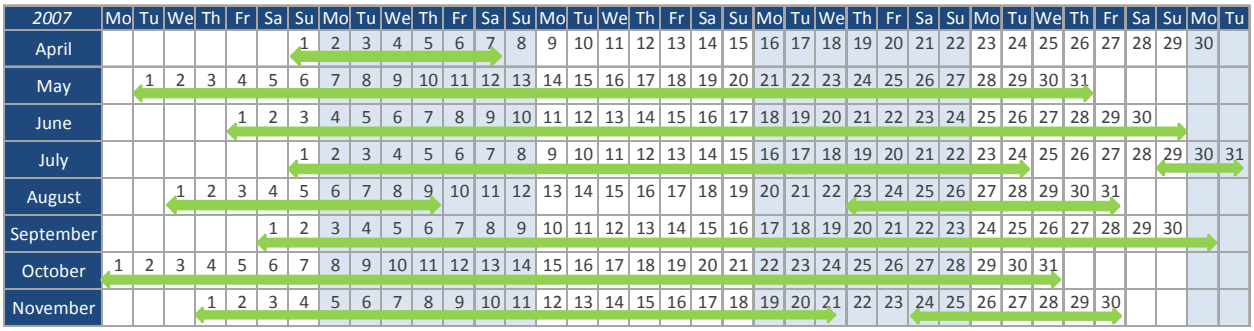
Most installations occurred in the Sacramento area. However, installation locations ranged from Woodland in the north to Fresno in the south, and from Rescue in the east to Vacaville in the west. Figure 5 indicates the areas where installations were performed. Areas of installation are indicated by red, dashed ovals. All but one area (Stockton) resulted in at least one calendar week of contiguous logging.

Figure 5. Equipment Instrumentation Sites
(www.google.com)



The original logging schedule was scheduled for the summer of 2007. However, various logistical, equipment, and participant issues resulted in significant delays to the schedule. As a result, logger installations occurred from the beginning of April until the end of November of 2007. Figure 6 shows the days during which loggers were operational.

Figure 6. Calendar Showing Days of Logger Operation



A total of 75 pieces of equipment had an operational logger installed for a contiguous week. Table 4 summarizes the pieces of equipment successfully instrumented for this project. The Unit ID corresponds to the date of installation. If more than one piece was installed on a given day, the serial number at the end of the ID differentiates between them. The "Activity Days" column lists the dates which produced activity data for the piece of equipment. Unit Type was assigned using the nomenclature provided by ARB. Only a few pieces were operated every day during the 7 days of installation. However, most pieces operated during 3 or more days of the week. This sample may have been biased toward equipment that operates less frequently than average. Fleet operators may have directed ERG installers to the less active pieces to minimize disruptions in their schedules.

As seen in the table there was substantial sampling on loaders, backhoes, and compactors due to their relative abundance and availability during the project. Unfortunately, no snow graders, rollers, pavers, or trenchers were successfully instrumented.

A more detailed discussion of the data logger findings is provided in Section 3.2.

Table 4. Instrumented Equipment Detail

Unit ID	Install Start	Activity Days	Install End	Unit Type	Make	Model	Engine Year
20070401-1	4/1/2007	1,2	4/7/2007	Loader	Caterpillar	IT 38G	2004
20070503-1	5/3/2007	3,4,8,9	5/9/2007	Loader	Case	W11	1981
20070508-1	5/8/2007	8,9,10,11	5/14/2007	Backhoe	Deere	310SG	2004
20070515-1	5/15/2007	15,16,17,18	5/21/2007	Backhoe			1998
20070515-2	5/15/2007	15,16,17,18,21	5/21/2007	Grinder	Peterson Pacific	5400	2002
20070515-3	5/15/2007	16,17,18	5/21/2007	Loader	Caterpillar		1983
20070516-1	5/16/2007	16,17,21	5/22/2007	Loader	Deere	640	
20070517-1	5/17/2007	17,18,22	5/23/2007	Backhoe	Terex	TX760	2002
20070521-1	5/21/2007	23,24,25	5/27/2007	Compactor	Caterpillar	825C	
20070522-1	5/22/2007	22,24,25,26,27	5/28/2007	Screener	Trommel		2006
20070522-2	5/22/2007	22,23,24,25	5/28/2007	Backhoe	Case		1997
20070523-1	5/23/2007	29	5/29/2007	Loader	Komatsu	WA250L	2005
20070524-1	5/24/2007	25,29,30	5/30/2007	Backhoe	Deere	310SE	2000
20070526-1	5/26/2007	30,31	6/1/2007	Loader	Caterpillar	953C	1999
20070529-1	5/29/2007	29,30,31,1,4	6/4/2007	Grinder			
20070529-2	5/29/2007	29,30,31,1,2	6/4/2007	Compactor	Caterpillar	836G	2004
20070530-1	5/30/2007	30,31,1,2,3,4,5	6/5/2007	Grader	Deere	872D	2005
20070530-2	5/30/2007	30,31,1,2,4,5	6/5/2007	Loader	Volvo	L150C	
20070531-1	5/31/2007	31,1,2,3	6/6/2007	Backhoe			
20070601-1	6/1/2007	4	6/7/2007	Backhoe	Deere	410G	2004
20070602-1	6/2/2007	4,5,6	6/8/2007	Backhoe	Caterpillar	430 EIT	2006
20070602-2	6/2/2007	3,4,5,6,7,8	6/8/2007	Loader	Caterpillar	IT 38G	2001
20070604-1	6/4/2007	4,5,6,7,8	6/10/2007	Dozer	Caterpillar	D9R	1996
20070605-1	6/5/2007	5,6	6/11/2007	Screener			
20070605-2	6/5/2007	5,6,7,8,10,11	6/11/2007	Compactor	Caterpillar	836G	2001
20070605-3	6/5/2007	5,6,7,8	6/11/2007	Backhoe	Deere	410G	2002

Unit ID	Install Start	Activity Days	Install End	Unit Type	Make	Model	Engine Year
20070606-1	6/6/2007	6,7,8,14	6/14/2007	Loader	Volvo	L150E	
20070606-2	6/6/2007	6,7,8,9,10	6/13/2007	Rubber Wheel Loader	Caterpillar	980	1998
20070607-1	6/7/2007	12	6/13/2007	Backhoe			
20070609-1	6/9/2007	9,10,11,12,13,14,15	6/15/2007	Loader	Caterpillar	953C	2000
20070612-1	6/12/2007	13	6/18/2007	Backhoe	Deere	710D	1998
20070614-1	6/14/2007	14,15,16,17,18,19,20	6/20/2007	Dozer	Caterpillar	D9R	2002
20070615-1	6/15/2007	15,16,18,21	6/21/2007	Loader	Caterpillar		1986
20070616-1	6/16/2007	16,17,18,19,20	6/22/2007	Loader	Caterpillar	950G	2002
20070622-1	6/22/2007	22,23,24,25,26	6/28/2007	Loader			
20070624-1	6/24/2007	25,26	7/1/2007	Loader	Caterpillar	966E	1990
20070628-1	6/28/2007	28,29,2,4	7/4/2007	Backhoe	Deere	310SE	2000
20070705-1	7/5/2007	5,6,7,9,10,11,12	7/12/2007	Backhoe	Deere	310SE	2000
20070709-1	7/9/2007	11,12,13	7/15/2007	Rubber Wheel Loader	Komatsu	WA250L	2005
20070716-1	7/16/2007	17,19,20	7/22/2007	Loader	Caterpillar	966	2003
20070718-1	7/18/2007	18,19,20,21,22,23,24	7/24/2007	Loader	Caterpillar	914G	
20070729-1	7/29/2007	29,30,31,1,2	8/4/2007	Backhoe	Deere	410SG	2001
20070803-1	8/3/2007	3,4,6,7,9	8/9/2007	Wheel Loader			
20070823-1	8/23/2007	23,24,27,29	8/29/2007	Backhoe	Deere	310SG	2004
20070824-1	8/24/2007	24,28,30	8/30/2007	Wheel Loader	Komatsu	WA450	
20070824-2	8/24/2007	24,25,27,28,29,30	8/30/2007	Scraper	Caterpillar	623F	
20070824-3	8/24/2007	24,27,29,30	8/30/2007	Dozer	Komatsu	D155AX	
20070826-1	8/26/2007	30,31	9/1/2007	Compactor	Caterpillar	815F	
20070830-1	8/30/2007	30,31,4	9/5/2007	Backhoe			
20070831-1	8/31/2007	31,4,5,6,7	9/7/2007	4WD Tractor Root Plow			
20070831-2	8/31/2007	4,5	9/6/2007	Wheel Loader	Caterpillar	980C	1986
20070831-3	8/31/2007	31,4,5,6,7	9/7/2007	Scraper	Caterpillar	623	2001
20070831-4	8/31/2007	31,4,6,7	9/7/2007	Dozer	Caterpillar	D9R	2001
20070906-1	9/6/2007	6,7,10,11,12,13,14	9/14/2007	Excavator	Komatsu	PC400	2004

Unit ID	Install Start	Activity Days	Install End	Unit Type	Make	Model	Engine Year
						LC	
20070907-1	9/7/2007	7,11,12,13,14	9/14/2007	Claw Tractor/Loader	Case	521 DXT	
20070913-1	9/13/2007	17,18,19	9/19/2007	Excavator	Volvo	EC290B	2006
20070917-1	9/17/2007	17,20,24,25	9/25/2007	Claw Tractor/Loader			
20070919-1	9/19/2007	20,21,24,25	9/26/2007	Excavator	Komatsu	PC400 LC	2004
20070923-1	9/23/2007	27,29	9/29/2007	Compactor			
20070926-1	9/26/2007	27,28,2	10/2/2007	Claw Tractor/Loader			
20070930-1	9/30/2007	1,3,4	10/6/2007	Wheel Loader			
20071004-1	10/4/2007	4,8,9,10,11	10/11/2007	Claw Tractor/Loader			
20071010-1	10/10/2007	10,11,16	10/17/2007	Rubber Wheel Loader	Caterpillar	950G	2002
20071018-1	10/18/2007	18,19,20,22,23,24	10/24/2007	Rubber Wheel Loader	Komatsu	WA250L	2006
20071025-1	10/25/2007	25,26	10/31/2007	Compactor	Pactor	3-30	1984
20071101-1	11/1/2007	1,2,5	11/7/2007	Compactor	Caterpillar	825G	
20071108-1	11/8/2007	8,13,14	11/14/2007	Compactor	Caterpillar	815B	1986
20071112-1	11/12/2007	12,14,15,17	11/18/2007	Rubber Wheel Loader	Caterpillar	980C	1987
20071115-1	11/15/2007	15,16,17,18,19	11/21/2007	Compactor	Pactor	3-30	1982
20071124-1	11/24/2007	24,30	11/30/2007	Compactor	Caterpillar	825G	1996

3.0 Results

The findings for the equipment survey and instrumentation tasks under Phase II of the study are presented below.

3.1 Equipment Survey Results

The data collected during the survey effort provides detailed information for a wide variety of off-road equipment types and end-users. The following sections provide general descriptive statistics as well as in-depth statistical analyses regarding equipment populations and characteristics directly influencing emissions estimates, including fuel types, activity profiles, hp distributions, and age distributions, among other factors.

3.1.1 Post-Processing and Quality Assurance

Once the survey results were compiled, formatted, and cleaned by the data collection subcontractor, the equipment data were subjected to additional range checks and quality assurance measures to ensure the quality and accuracy of the data set. Evaluations focused on assuring accurate assignment of equipment to appropriate OFFROAD model equipment categories, identification of missing hp values, refinement of equipment application assignments, excluding any non-target equipment, and identification and treatment of suspected outliers. The following describes the various quality assurance measures applied to the survey data set.

Equipment Category Assignments

ERG used the equipment list in ARB's OFFROAD equipment file to map respondent equipment descriptions to the standardized equipment listing. Assignments were based on the contractor's familiarity with off-road equipment types as well as web searches. There were many instances where a corresponding equipment type could not be found in ARB's OFFROAD file. In these instances, the original respondent equipment type description was retained. Another exception involved equipment that was electrically powered or manually operated. In these cases, regardless of equipment type, an equipment type of "Electric" or "Manual" was assigned and these records were set aside from the rest of the data tables for later ARB evaluation. Table 5 summarizes the electric equipment type descriptions reported by survey sector.

Table 6 provides a list of unique respondent equipment types and the corresponding ARB equipment type. Non-electric equipment for which no clear category match was established were subsequently grouped together in "Miscellaneous" categories, as discussed later in this report (see Table 7).

Table 5. Electric Equipment Type Descriptions by Survey Sector

Equipment Category	Agricultural	Construction & Mining	Residential	Residual	Total
Air Compressor(s)		93	3	151	**247**
Air Conditioner				1	**1**
Air Scrubber		1			**1**
Bailer(s)				2	**2**
Belt Sander			1		**1**
Bench Saw				1	**1**
Bender		1			**1**
Book Maker				2	**2**
Brakes		2			**2**
C & C Machine				5	**5**
Car Lift				2	**2**
Cart(s)				4	**4**
Cement Mixer		1			**1**
Centrifuge		1			**1**
Chainsaw(s)			8		**8**
Compressor		1			**1**
Cutter				2	**2**
Dehumidifier		2			**2**
Drill Motor			1		**1**
Drill(s)		18	6	6	**30**
Dynamometer				1	**1**
Forklift(s)		1		15	**16**
Generator Set(s)		1		1	**2**
Golf Cart(s)	4	1	2	20	**27**
Hydro-pump		1			**1**
Ice-Machines				2	**2**
Irrigation Set(s)	1				**1**
Jack Hammer		5			**5**
Lathe			1		**1**
Lawn Mower(s) (Walk Behind)			17		**17**
Leaf Blower(s) (Hand Held)			29	1	**30**
Man Lift(s)		2		3	**5**
Mill				5	**5**
Milling Machine				5	**5**
Orbital Sander			2		**2**
Outside Vacuum			1		**1**
Pallet Jack				1	**1**
Panel Saws				1	**1**
Pipe Threader		17			**17**
Polisher		1			**1**
Precrusher				1	**1**
Pressure Washer(s)		1			**1**
Pump(s)	1				**1**
Reciprocal Saw			1		**1**
Refrigeration Compressors				8	**8**
Sand Blaster			1		**1**

Equipment Category	Agricultural	Construction & Mining	Residential	Residual	Total
Saw		3			**3**
Screw Driver		4			**4**
Shop Vacuum			2		**2**
Skill Saw		1	3		**4**
Splitter		1			**1**
Spray Booth				1	**1**
Sprayer(s)		3	1		**4**
Table Classifier		1			**1**
Table Saw			1	4	**5**
Tile Saw		1		6	**7**
Trimmer/Edger/Brushcutter			54		**54**
Vacuum				3	**3**
Vertical Milling Machine				5	**5**
Water Extractor		1			**1**
Welder(s)		6		7	**13**
Well	1				**1**
Wire Puller		1			**1**
Zapper Saw			1		**1**
Total	**7**	**172**	**135**	**266**	**580**

Table 6. Respondent Equipment Types and Corresponding ARB Equipment Type Assignments

Respondent Equipment Types	ARB Equipment Mapping		Respondent Equipment Types	ARB Equipment Mapping
Aerial Lift(s)	Aerial Lifts		Mill	***Mill****
Ag Wells	***Ag Wells****		Minibike(s)	Minibikes
Agricultural Mower(s)	Agricultural Mowers		Mixer	Cement and Mortar Mixers
Agricultural Tractor(s)	Agricultural Tractors		Motor Boat	Vessels w/Outboard Engines
Air Compressor	Air Compressors		Off-Highway Truck(s)	Off-Highway Trucks
Air Compressor(s)	Air Compressors		Off-Road Motorcycle(s)	Off-Road Motorcycles Active
Air Conditioner	Air Conditioner		Orbital Sander	***Orbital Sander****
Air Scrubber	***Air Scrubber****		Out Board Engine	Vessels w/Outboard Engines
All Terrain Vehicle(s)	All Terrain Vehicles (ATVs)		Outside Vacuum	Leaf Blowers/Vacuums
Backhoe(s)	Tractors/Loaders/Backhoes		Pallet Jack	***Pallet Jack****
Bail Hauler	***Bale Hauler****		Panel Saws	***Saw****
Bailer(s)	Balers		Paver(s)	Pavers
Balancer	***Balancer****		Paving Equipment	Paving Equipment
Belt Sander	***Belt Sander****		Personal Water Craft	Personal Water Craft
Bench Saw	***Saw****		Pick Up	***Onroad****
Bender	***Bender****		Pipe Threader	***Pipe Threader****
Boat	Vessels w/Outboard Engines		Pipe Threading Machine	***Pipe Threading Machine****
Boat Motor	Vessels w/Outboard Engines		Plaster Mixer	Cement and Mortar Mixers
Boat Outboard Motor	Vessels w/Outboard Engines		Polisher	***Polisher****
Bob Cat	Skid Steer Loaders		Precrusher	***Precrusher****
Bobcat	Skid Steer Loaders		Pressure Washer(s)	Pressure Washers
Book Maker	***Book Maker****		Pump(s)	Pumps
Brakes	***Brakes****		Reciprocal Saw	***Saw****
Brush Cutter(s)	Trimmers/Edgers/Brush Cutters		Refrigeration Compressors	***Compressor (Other) ****
Bulldozer(s)	Crawler Tractors		Riding Lawn Mower	Front Mowers
C And C Machine	***C and C Machine****		Riding Lawn Mower(s)	Front Mowers
Car Lift	***Car Lift****		Roller(s)	Rollers
Cargo Loader(s)	Cargo Loader		Sand Blaster	***Sand Blaster****
Cart(s)	Cart		Saw	***Saw****
Caterpillar	***Unknown Caterpillar****		Scraper(s)	Scrapers
Cement Mixer	Cement and Mortar Mixers		Screw Driver	***Screw Driver****
Centrifuge	***Centrifuge****		Service Truck(s)	Service Truck

Respondent Equipment Types	ARB Equipment Mapping		Respondent Equipment Types	ARB Equipment Mapping
Chainsaw(s)	Chainsaws		Shaker	***Shaker****
Chainsaw(s) (Lt 5 Hp)	Chainsaws		Shop Vacuum	***Shop Vac****
Champ	***Champ****		Shredder(s) (> 5Hp)	Shredders
Chipper	Chippers/Stump Grinders		Skid Steer Loader(s)	Skid Steer Loaders
Chop Bag	***Shop Vac****		Skidder(s)	Skidders
Combine(s)	Combines		Skill Saw	***Saw****
Compactor	Rollers		Skytrack	Aerial Lifts
Compressor	***Compressor (Other) ****		Snow Blower	Snowblowers
Concrete Saw	Concrete/Industrial Saws		Snow Mobile	Snowmobiles Active
Crane(s)	Cranes		Specialty Vehicle Cart(s)	Specialty Vehicles Carts
Cultivator	Tillers		Splice	***Splice****
Cut Off Saw	Concrete/Industrial Saws		Splitter	***Splitter****
Cutter	***Cutter****		Spray Booth	***Electric****
Dehumidifier	***Dehumidifier****		Sprayer(s)	Sprayers
Diesel Motor	***Diesel Motor****		Spreader	***Spreader****
Dipswitch	Signal Boards		Storm Grinders	***Storm Grinder****
Dirt Compactor	Rollers		Strain Trimmer	Trimmers/Edgers/Brush Cutters
Dirt Remover	***Dirt Remover****		Swamp Cooler	***Electric****
Drill Motor	***Drill Motor****		Swather(s)	***Swathers****
Drill(s)	***Drills****		Sweeper	Sweepers/Scrubbers
Drilling Rig(s)	Bore/Drill Rigs		Sweeper(s)/Scrubber(s)	Sweepers/Scrubbers
Dynamometer	***Dynamometer****		Table Classifier	***Table Classifier****
Edger	Trimmers/Edgers/Brush Cutters		Table Saw	***Saw****
Electric Lawn Mower	***Electric****		Tamper	Tampers/Rammers
Electric Skill Saw	***Electric****		Terminal Tractor(s)	Terminal Tractors
Electric Weed Whacker	***Electric****		Thatcher	***Thatcher****
Excavator(s)	Excavators		Tile Cutter	***Saw****
Feed Feeder	***Feed Feeder****		Tile Saw	***Saw****
Fire Pump	Pumps		Tiller(s)	Tillers
Fishing Boat	Vessels w/Outboard Engines		Tire Balancer	***Tire Balancer****
Industrial forklift(s)	Industrial forklifts		Tire Changer	***Tire Changer****
Fuel Pump	Pumps		Tractor(s)	Tractors/Loaders/Backhoes
Generator Set(s)	Generator Sets		Transportation Refrigeration	Transport Refrigeration Units

Respondent Equipment Types	ARB Equipment Mapping		Respondent Equipment Types	ARB Equipment Mapping
			Unit(s)	
Golf Cart	Golf Carts		Trash Pumps	Pumps
Golf Cart(s)	Golf Carts		Trencher(s)	Trenchers
Grader(s)	Graders		Trimmer	Trimmers/Edgers/Brush Cutters
Harvester(s)	Combine(s)		Underground Saw	***Saw****
Hedge Trimmer	Trimmers/Edgers/Brush Cutters		Vacuum	***Vacuum****
High Ranger Bucket Truck	Aerial Lifts		Vacuum Cleaner	***Vacuum****
Hot Tar Pump	Pumps		Vacuum	***Vacuum****
Hunter Alignment Rack	***Hunter Alignment Rack****		Vacuum Pot Holing (Excavating)	***Vacuum Pot Holing (excavating) ****
Hydro Power Unit(s)	Hydro Power Units		Vertical Milling Machine	***Milling Machine***
Hydropump	Hydro Power Units		Wacker	Trimmers/Edgers/Brush Cutters
Ice-Machines	***Ice Machine****		Water Boiler	***Boiler****
Industrial Tractor(s)	Rubber Tired Loaders		Water Extractor	***Water Extractor****
Irrigation Set(s)	***Irrigation Sets****		Wave Rider	Personal Water Craft
Jack Hammer	***Jack Hammer****		Weed Eater	Trimmers/Edgers/Brush Cutters
Jet Skies	Personal Water Craft		Weed Wacker	Trimmers/Edgers/Brush Cutters
John Deere	***Unknown John Deere****		Weed Whacker	Trimmers/Edgers/Brush Cutters
Lawn Edger(s)	Trimmers/Edgers/Brush Cutters		Welder(s)	Welders
Lawn Mower(s) (Walk Behind)	Lawn Mowers		Well	***Well****
Lawn Trimmer(s) / Edger(s)	Trimmers/Edgers/Brush Cutters		Whacker	Trimmers/Edgers/Brush Cutters
Lays	***Lathe****		Wire Puller	***Electric****
Leaf Blower(s) (Back Pack)	Leaf Blowers/Vacuums		Wood Chipper	Chippers/Stump Grinders
Leaf Blower(s) (Hand Held)	Leaf Blowers/Vacuums		Woodsplitter	Wood Splitters
Line Trimmer	Trimmers/Edgers/Brush Cutters		Yard Burn	***Yard Burn****
Loader(s)	Rubber Tired Loaders		Yard Truck	***Yard Truck****
Man Lift(s)	Aerial Lifts		Yard Vacuum	Leaf Blowers/Vacuums
Manual Milling Machine	***Manual****		Zaper Saw	***Saw****

Respondent Equipment Types	ARB Equipment Mapping		Respondent Equipment Types	ARB Equipment Mapping
Massey Ferguson	***Unknown Massey Ferguson****			
Material Handling Equipment (e.g., Conveyors, Rock Crushers)	***Materials Handling (Other) ****			

*No exact ARB category match determined

Horsepower Assignments

In cases where the respondent did not provide a specific horsepower value for a piece of equipment, horsepower assignments were made based on the following decision rules, presented in order of precedence.

A. Where equipment make and model were provided, web searches were utilized to find hp information when available.
B. Where a hp range was provided, the average of the minimum and maximum horsepower range was used. Standard hp ranges provided to respondents included:

- < 11;
- 11 – 24;
- 25 – 49;
- 50 – 74;
- 75 – 119; and
- 120 – 174.

Application Category Assignments

The survey included several standardized use categories including:

- Agricultural production and harvesting;
- Automotive;
- Building or construction;
- Industrial;
- Other (e.g., cleaning or maintenance) – to be specified;
- Personal or residential;
- Recreational; and
- Warehousing.

In some instances when a respondent selected the "Other" category, the additional description provided by the respondent fit within one of the standardized uses originally presented to them. In these instances, the use was changed from "Other, specify" to the appropriate use from the standardized list. The most common reassignments moved "lawn care," "lawn maintenance," "yard care," and "gardening" to the Personal/Residential category.

Excluded Records

Some records were excluded from the data set based on answers indicating they were ineligible for inclusion in the study. The number of non-electric records excluded from analyses, and on what basis they were excluded, are summarized in Table 7.

Table 7. Basis and Count of Excluded Records

Reason for Exclusion	# of Records
Zero Hours Operation	133
On-road Equipment	14
Outside hp Range	15
Manual Operation	3
Pneumatic Equipment	1
Refusal to Provide Equipment Info[6]	1
Total Records	**167**

Outlier/Anomaly Identification

Some respondent answers for horsepower and/or activity were identified as outliers, either too high or too low, based on: horsepower ranges presented in ARB's OFFROAD model, hp ranges presented in EPA's NONROAD2005 model,(7) comparison with other respondent answers, known acceptable fuel types for specific equipment types, or, in the case of activity, the number of hours in a year. In consultation with ARB the contractor flagged suspect values for further investigation. In these instances, the data collection subcontractor made an initial round of call-backs to obtain clarification. Later, the contractor attempted to contact remaining respondents for clarification. A summary of the second round of survey call-backs is presented in Table 8.

Table 8. Call Summary – Second Round Call-backs

Number of Respondents Identified for Call-backs	162
Number of Records with Outliers/Anomalies	392
Number of Call-backs Attempted	119
No Answer	16
Left Message	51
Fax Number	3
Disconnected Number	4
Other Miscellaneous Responses	9
Number of Respondents without Contact Information	6
Number of Respondents Identified - Not Called*	39
Number of Records Updated	27
Number of Records Verified as Correct	19

*These represent records in the construction sector that had a seemingly low horsepower or activity upon initial QA. After several phone calls to these types of outliers within this sector, it became apparent that these low numbers were acceptable due to very limited use.

3.1.2 Survey Rates

As shown in Table 9, the combined results from the pilot and full-study totaled 1,164 completed surveys, exceeding the study goal of 1,100.

[6] Respondent indicating owning/operating a piece of covered equipment but would not specify type or other data.

Table 9. Completed Questionnaires by Sample Type

Sample Type	Target # of Completes	Actual # of Completes	Percent Actual
Agriculture	275	298	26%
Construction and Mining	225	246	21%
Residuals	275	293	25%
Residential	325	327	28%
Total	**1,100**	**1,164**	**100%**

Surveys that were completed over and above the expected number were the result of the mixed-mode administration of the survey (i.e., additional mail-in questionnaires were received after telephone interviews were conducted).

In order to determine how the survey "performed" for each sample type, disposition tables were developed to provide results for all sample records identified for the pilot survey, as well as assorted survey response parameters. Table 10 provides a description of the final dispositions for all sample records that were used during the pilot and full-study surveys, by response sector.

Table 10. Final Dispositions for Final Off-road Sample

Survey Parameter	Agriculture		Const/Mining		Residual		Residential		Total	
	Count	%	Count	%	Count	%	Count	%	Count	%
Sample Pieces Used	4,146	100%	5,785	100%	4,215	100%	9,404	100%	23,550	100%
Completed Surveys	298	7%	246	4%	293	7%	327	3%	1,164	5%
Eligible to Participate	385	9%	310	5%	377	9%	396	4%	1,468	6%
Ineligible to Participate	385	9%	1,001	17%	1,278	30%	1,257	13%	3,921	17%
Average Interview Length (Phase I)	18.6	Minutes	13.6	Minutes	24.1	Minutes	11.6	Minutes	--	--
Average Interview Length (Phase II full study)	14.67	Minutes	11.3	Minutes	11.18	Minutes	9.83	Minutes	--	--
Completes per Hour (cph) (Phase I)	0.19	CPH	0.24	CPH	0.27	CPH	0.34	CPH	--	--
Completes per Hour (cph) (Phase II full study)	1.06	CPH	0.61	CPH	0.27	CPH	0.63	CPH	--	--

The great majority of the sample was of unknown eligibility, meaning that either contact was never made with that record or the call resulted in a callback or a soft refusal prior to eligibility being determined.[7] Overall, once contact was made with an eligible equipment operator the vast majority of operators went on to complete the survey (1,164 of 1,468).[8] A large number of phone contacts were made with ineligible parties (i.e., entities that did not own/operate any off-road equipment < 175 hp.) The incidence rate (the ratio of ineligible to eligible respondents) was

[7] A soft refusal is someone who initially says they won't participate in the survey. They are called back until they make it clear they have no intention to participate.

[8] Eligible respondents responded "yes" to the questions: (1) do you own or lease at least one piece of off-road equipment, and (2) does that equipment have a maximum horsepower rating of less than 175?

highest for the Agricultural Sector, at 50%. The incidence rates for the remaining three sectors were all quite close, between 23% and 24%.

The differences in incidence rates are also reflected by the "completes per hour" values shown in Table 10. These data indicate a substantial increase in data collection efficiency for the full study compared with the Phase I pilot.

3.1.3 Respondent Profiles

Profiles were developed to broadly characterize the survey respondents, in order to qualitatively demonstrate broad representativeness of off-road equipment operators as a whole. Detailed statistical analyses, including confidence intervals, are presented in Section 4 for each equipment/fuel type combination.

Because of the extreme variation within the agricultural industry (e.g., types of crop, acreage range), the agriculture sample was further broken down into six segments to ensure representation within the industry's multiple crops: Tree Fruit (apricots, peaches, lemons, etc), Row Crops, Nut Crops, and Other Crops (including vineyards), Farm Management Companies and CAFO/Dairy.[9] For a complete listing of crop category assignments, see Appendix A.

Tables 11 thru 14 summarize the number of completes by respondent type within the Agriculture, Construction and Mining, Residential, and Residual Sectors, respectively. Completed surveys for the Agriculture sector in Table 11 are also reported by geographic area, distinguishing respondents within the San Joaquin Valley (SJV) from those in the rest of the state.[10] SIC breakouts for the Construction and Residential sectors were selected to reflect different equipment utilization patterns, based on contractor experience.

Table 11. Completed Surveys by SSI Crop/Service Type – Agricultural Sector

Crop/Service Type	Completed Surveys		Total	Percentage
	SJV	Other Areas		
Tree Fruit	3	10	13	4%
Row Crop	38	42	80	27%
Nut Crop	49	13	62	21%
Other Crop	41	74	115	39%
Farm Management	8	4	12	4%
CAFO/Dairy	2	14	16	5%
Total	**141**	**157**	**298**	**100%**

[9] CAFO – Concentrated Animal Feeding Operations.
[10] SJV consisting of Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare counties.

Table 12. Completed Surveys by SIC Group – Construction and Mining Sector

SIC Group Description	SIC	Total
Heavy-Highway	1611, 1622	13
Other Heavy Construction	1629	5
Utility	1623	2
Residential Buildings	1521, 1522, 1531	42
Other Buildings	1541, 1542	10
Special Trades - Excavation	1794	10
Special Trades - Other - all other	1700s (less 1794)	149
Mining	1000s, 1200s, 1400s	15
Total		**246**

Table 12 indicates a predominance of respondents in the residential building and "special trades – other" category.

Table 13. Completed Surveys by Region – Residential Sector

Residence Area	Total	Percentage
Non Target	240	73%
Target	87	27%
Total	**327**	**100%**

Table 14. Completed Surveys by SIC Group – Residual Sector

SIC Group Description	SIC	Total
Division A - Non Agricultural	100s – 999, excluding 0711, 0721, 0722, 0762 (Farm Mgmt.)	22
Manufacturing	2000 – 3999	75
Public Administration	9000 – 9999	3
Services	7000 – 8999	85
Transportation, Communications, Electric Gas and Sanitary Services	4000 – 4999	17
Wholesale Trade	5000 - 5199	41
Retail Trade	5200 - 5999	50
	Total	**293**

The respondents in the Residual sector were relatively dispersed across a wide range of SIC groupings, although only a small number fell in the government category (i.e., public administration).

The respondent categories listed in Table 11 were obtained directly from SSI, the sample provider for the Agricultural Sector. Eligible respondents were subsequently asked to categorize their operations by crop type, as shown in Table 15. This crop type categorization, based on stakeholder recommendations, provides slightly more detail than the SSI categories. In addition, respondents reporting to provide Farm Management services (39 of the 298 completes) also reported the crop type they typically service: citrus, one; CAFO/dairy, two; nut, 10; row, 12; other tree fruit, eight; and vineyards/other, six.

Table 15. Completed Agricultural Surveys by Self-Reported Crop Type

Crop Type	Completes - SJV	Completes – Other Areas	Total Completes
Tree Fruit (non citrus)	18	36	54
Row Crop	26	36	62
Nut Crop	40	14	54
Vineyard/Other Crop	29	42	71
Citrus	15	16	31
CAFO/Dairy	13	13	26
Total	**141**	**157**	**298**

This study assumed the self-reported crop type provides a more accurate representation of respondent operations than the sample frame categories, and was used for subsequent analyses.

Table 16 provides a detailed breakout of the acreage covered by county for the acreage covered by the survey. The table also provides the total acreage in farms by county from the 2002 Agricultural Census (8). Survey coverage appears broadly representative of the state, with 55% of surveyed acreage occurring within the SJV which contains 50% of the state's agricultural land.

Table 16. Completed Surveys and Associated Acreage by County – Ag. Sector

County	Responses*	Acreage*	Percent of Survey	Acreage 2002 Census	Percent of Census
Alameda	2	1,300	2.13%	10,608	0.07%
Alpine	-	0	0.00%	850	0.01%
Amador	-	0	0.00%	10,387	0.07%
Butte	3	2,735	4.48%	435,419	2.88%
Calaveras	-	0	0.00%	4,796	0.03%
Colusa	1	300	0.49%	531,573	3.51%
Contra Costa	3	80	0.13%	41,933	0.28%
Del Norte	-	0	0.00%	3,567	0.02%
El Dorado	7	211	0.35%	10,794	0.07%
Fresno^	32	5,380	8.82%	1,869,960	12.36%
Glenn	14	1,320	2.16%	407,889	2.70%
Humboldt	1	58	0.10%	17,285	0.11%
Imperial	2	2,700	4.42%	725,045	4.79%
Inyo	-	0	0.00%	3,805	0.03%
Kern^	2	360	0.59%	1,327,926	8.77%
Kings^	7	1,367	2.24%	364,399	2.41%
Lake	-	0	0.00%	43,896	0.29%
Lassen	-	0	0.00%	43,245	0.29%
Los Angeles	2	70	0.11%	38,756	0.26%
Madera^	4	2,376	3.38%	512,209	3.38%
Marin	-	0	0.00%	5,300	0.04%
Mariposa	-	0	0.00%	761	0.01%
Mendocino	3	710	1.16%	54,911	0.36%
Merced^	10	1,730	2.82%	699,471	4.62%

County	Responses*	Acreage*	Percent of Survey	Acreage 2002 Census	Percent of Census
Modoc	1	210	0.34%	113,848	0.75%
Mono	-	0	0.00%	13,114	0.09%
Monterey	-	0	0.00%	1,084,704	7.17%
Napa	7	610	1.00%	103,412	0.68%
Nevada	-	0	0.00%	4,124	0.03%
Orange	3	667	1.09%	20,232	0.13%
Placer	1	>1	0.00%	39,268	0.26%
Plumas	-	0	0.00%	9,138	0.06%
Riverside	8	1,590	2.61%	385,915	2.55%
Sacramento	4	3,618	5.93%	187,224	1.24%
San Benito	-	0	0.00%	103,670	0.68%
San Bernardino	8	239	0.39%	63,131	0.42%
San Diego	29	1,611	2.64%	180,460	1.19%
San Francisco	-	0	0.00%	0	0.00%
San Joaquin^	18	6,268	10.27%	916,279	6.05%
San Luis Obispo	-	0	0.00%	228,282	1.51%
San Mateo	-	0	0.00%	15,041	0.10%
Santa Barbara	5	1,200	1.97%	315,348	2.08%
Santa Clara	1	23	0.04%	47,010	0.31%
Santa Cruz	-	0	0.00%	86,329	0.57%
Shasta	2	95	0.16%	22,740	0.15%
Sierra	-	0	0.00%	2,800	0.02%
Siskiyou	1	500	0.82%	132,873	0.88%
Solano	2	1,020	1.67%	189,716	1.25%
Sonoma	5	1,324	2.17%	158,008	1.04%
Stanislaus^	13	8,382	13.74%	640,572	4.23%
Sutter	5	416	0.68%	521,906	3.45%
Tehama	1	200	0.33%	126,471	0.84%
Trinity	-	0	0.00%	932	0.01%
Tulare^	42	9,076	14.87%	1,273,612	8.42%
Tuolumne	2	229	0.38%	1,094	0.01%
Ventura	14	2,244	3.68%	308,709	2.04%
Yolo	6	750	1.23%	514,551	3.40%
Yuba	1	75	0.12%	159,130	1.05%
Total	**272**	**61,025**	**100.00%**	**15,134,428**	**100.00%**

* Does not include responses or acreage from CAFO/Dairy

^ SJV counties

Tables 17, 18, and 19 present the number of completed surveys by county for the Construction and Mining, Residential, and Residual sectors, respectively.

Table 17. Completed Surveys by County – Construction and Mining Sector

County	# Completes		County	# Completes
Alameda	6		Riverside	11
Butte	1		Sacramento	6
Calaveras	1		San Benito	1
Colusa	1		San Bernardino	13
Contra Costa	5		San Diego	12
El Dorado	3		San Francisco	2
Fresno	10		San Joaquin	8
Glenn	2		San Luis Obispo	8
Imperial	2		San Mateo	3
Inyo	1		Santa Barbara	3
Kern	7		Santa Clara	7
Kings	2		Santa Cruz	3
Los Angeles	40		Shasta	3
Madera	4		Siskiyou	4
Marin	3		Solano	1
Mendocino	3		Sonoma	8
Merced	1		Stanislaus	6
Monterey	5		Tehama	1
Napa	4		Tulare	5
Nevada	1		Tuolumne	1
Orange	21		Ventura	6
Placer	8		Yolo	3
			Total	**246**

Table 18. Completed Surveys by County – Residential Sector

County	# Completes		County	# Completes
Alameda	8		Placer	18
Amador	1		Riverside	15
Butte	7		Sacramento	5
Calaveras	1		San Bernardino	13
Colusa	1		San Diego	17
Contra Costa	11		San Joaquin	7
El Dorado	6		San Luis Obispo	5
Fresno	9		San Mateo	3
Glenn	1		Santa Barbara	6
Humboldt	4		Santa Clara	10
Imperial	11		Santa Cruz	6
Kern	9		Shasta	4
Kings	1		Siskiyou	2
Lake	61		Solano	3
Los Angeles	22		Sonoma	5
Marin	1		Stanislaus	6
Mendocino	1		Sutter	2
Merced	3		Tulare	6

County	# Completes		County	# Completes
Monterey	7		Tuolumne	1
Napa	7		Ventura	4
Nevada	4		Yolo	3
Orange	9		Yuba	1
			Total	**327**

Table 19. Completed Surveys by County – Residual Sector

County	# Completes		County	# Completes
Alameda	9		Sacramento	14
Butte	1		San Bernardino	13
Calaveras	1		San Diego	19
Colusa	2		San Francisco	2
Contra Costa	5		San Joaquin	8
El Dorado	2		San Luis Obispo	4
Fresno	11		San Mateo	4
Glenn	2		Santa Barbara	4
Humboldt	2		Santa Clara	14
Imperial	2		Santa Cruz	5
Kern	7		Shasta	2
Kings	2		Sierra	1
Los Angeles	48		Siskiyou	3
Madera	1		Solano	6
Mariposa	1		Sonoma	8
Mendocino	9		Stanislaus	12
Merced	2		Tehama	3
Monterey	2		Trinity	2
Napa	1		Tulare	4
Nevada	1		Tuolumne	2
Orange	22		Ventura	9
Placer	4		Yolo	5
Riverside	11		Yuba	1
			Total	**293**

Agriculture respondents other than CAFO/Dairy were also asked to provide information on their associated total acreage. The average acreage per farm for each crop type is provided in Table 20, with row crops having the largest average size and tree fruit the smallest.

Table 20. Agricultural Respondent Mean Acreage by Crop Type

Crop Type	Mean Acreage Owned or Leased	
	SJV	*Other Areas*
Nut Crop	340	186
Row Crop	192	266
Tree Fruit (non-citrus)	90	144
Citrus	110	93
Vineyard/Other	450	173

Tables 21, 22, 23, and 24 summarize the average, minimum, and maximum number of pieces of equipment owned or operated by the respondents for each of the survey sectors. These summary tables provide a general indication of the variability in fleet sizes for the different sectors.

Table 21. Agricultural Respondent Pieces of Equipment by Crop/Service Type

Crop/Service Type	Number of Pieces of Equipment/Respondent							
	SJV				*Other Areas*			
	Avg.	Min	Max	Variance	Avg.	Min	Max	Variance
Nut Crop	5.4	1	23	28.8	3.9	1	8	5.9
Row Crop	3.2	1	7	3.8	3.9	1	17	12.9
Tree Fruit (non-citrus)	3.1	1	10	4.9	3.3	1	15	13.1
Citrus	3.3	1	11	6.8	3.3	1	9	8.2
Vineyard/Other	8.2	1	65	151.0	4.1	1	19	23.4
CAFO/Dairy	3.5	1	6	1.6	3.8	1	10	6.5

The variance of the distribution is also shown, indicating a relatively wide distribution across fleet size for the vineyard/other category in the SJV. Much of this variation is due to a single respondent operating 65 pieces of equipment, with the next largest fleet consisting of only 25 units.

Table 22. Construction and Mining Respondent Pieces of Equipment by Service Type

Service Type	Average	Min	Max	Variance
Construction	2.9	1	30	15.0
Mining	4.1	1	20	25.5

The construction and mining respondents show a somewhat wider distribution in fleet sizes relative to most of the agricultural crop/service type fleet.

Table 23. Residential Respondent Pieces of Equipment by Region

Respondent Area	Average	Min	Max	Variance
Non Target	2.2	1	14	3.4
Target	2.2	1	9	2.7

The residential sector exhibits the tightest distribution of the four survey sectors, as expected.

Table 24. Residual Respondent Pieces of Equipment by Service Type

Service Type	Average	Min	Max	Variance
Logging	6.2	1	23	47.2
Residual	2.9	1	130	70.6

Not surprisingly the residual sector shows the widest variance in fleet sizes of the four survey sectors, likely due to the variety of SICs included in this sector.

3.1.4 Response Weightings

After the survey data had been quality assured and cleaned, analytic weights were developed to reflect selection probabilities as well as to adjust for potential non-response bias. For example, it is possible that businesses with larger equipment inventories may not participate at the same rate as businesses that use little or no eligible equipment. Such differential non-response could bias the results of the survey because the commercial distribution of surveyed off-road equipment users would not represent the population distribution of businesses using off-road equipment. To illustrate, if businesses with only one piece of eligible off-road equipment participated in the survey at twice the rate as businesses with two or more pieces of eligible equipment, then the estimated total pieces of equipment based only on the survey data (i.e., without adjustment) would understate the actual population total. For this reason analytic weights were developed to correct for this type of bias for both the residential and commercial samples, as discussed below.

A total of 1,164 completed surveys of eligible respondents were collected. Table 25 summarizes the distribution of these surveys across sample type. In this case Agricultural sample types refer to SSI categorizations rather than self-reported crop types (see Table 11).

Table 25. Distribution of Completed Surveys by Sample Type – Unweighted

Sample Type 1	Sample Type 2	Frequency
Agriculture	Nut Crop	62
Agriculture	Row Crop	80
Agriculture	Tree Fruit	13
Agriculture	Other	115
Agriculture	Farm Management	12
Agriculture	CAFO/Dairy	16
Construction/Mining	Construction	231
Construction/Mining	Mining	15
Residual/Logging	Logging	13
Residual/Logging	Residual	280
Residential	Target	87
Residential	Non-target	240
	Total	**1,164**

As discussed above, two separate sample frames were used for the selection of the commercial (non-residential) sample data. The first source was an agriculture database maintained by SSI. In addition to administrative data such as name, address and phone number, the full-coverage nationwide database of farmers contains crop type and reported income from the sale of crops. The second source was SSI's B2B database, which contains a comprehensive list of nationwide

businesses based on the Dunn and Bradstreet SIC code database.[11] Table 26 identifies the sample frame from which each commercial sample type was drawn.

Table 26. Commercial Surveys by Sample Type – Sample Frame

Sample Type 1	Sample Type 2	Frame
Agriculture	Nut Crop	Agriculture Database
Agriculture	Row Crop	Agriculture Database
Agriculture	Tree Fruit	Agriculture Database
Agriculture	Other	Agriculture Database
Agriculture	Farm Management	SIC Database
Agriculture	CAFO/Dairy	Agriculture Database
Construction/Mining	Construction	SIC Database
Construction/Mining	Mining	SIC Database
Residual/Logging	Logging	SIC Database
Residual/Logging	Residual	SIC Database

Weights were created at the subsample level (sample type 2) for the agricultural sector. Due to the large number of completed surveys collected within the construction sector, and the wide range of establishment types present (and corresponding wide range of SIC codes), the construction category was further stratified into three microstrata (construction-a, construction-b, construction-c). Similarly, the residual category was stratified into six microstrata (residual-a through residual-f). Each construction and residual microstratum represents a grouping of similar establishment types (based on SIC division and/or major group). Table 27 provides a detailed breakdown of corresponding SIC grouping by various levels of stratification.

Table 27. Sample Type, Sample Frame and Corresponding SIC Grouping – Commercial Sectors

Sample Type 1	Sample Type 2	Microstrata	Frame	SIC Grouping
Agriculture	Nut Crop	N/A	Ag. Database	Codes 0173, 0179 (partial)
Agriculture	Row Crop	N/A	Ag. Database	Industry Group 011, 013
Agriculture	Tree Fruit	N/A	Ag. Database	Codes 0174, 0175, 0179 (partial)
Agriculture	Other	N/A	Ag. Database	Codes 0161, 0171, 0172, 0191
Agriculture	Farm Management	N/A	SIC Database	Codes 0711, 0721, 0722, 0762
Agriculture	CAFO/Dairy	N/A	SIC Database	Industry Group 021, 024
Construction/Mining	Construction	Construction-a	SIC Database	Major Group 15
Construction/Mining	Construction	Construction-b	SIC Database	Major Group 16
Construction/Mining	Construction	Construction-c	SIC Database	Major Group 17
Construction/Mining	Mining	N/A	SIC Database	Major Groups 10, 12, 14
Residual/Logging	Logging	N/A	SIC Database	Industry Group 241
Residual/Logging	Residual	Residual-a	SIC Database	Division A - Non Ag
Residual/Logging	Residual	Residual-b	SIC Database	Divisions D, E
Residual/Logging	Residual	Residual-c	SIC Database	Division F

[11] Dunn and Bradstreet is the industry standard for drawing samples of establishments for commercial surveys.

Sample Type 1	Sample Type 2	Microstrata	Frame	SIC Grouping
Residual/Logging	Residual	Residual-d	SIC Database	Major Groups 52, 53, 54, 55, 57
Residual/Logging	Residual	Residual-e	SIC Database	Major Groups 70, 75, 78, 79, 82, 84
Residual/Logging	Residual	Residual-f	SIC Database	Major Groups 91, 92, 97

In broad terms, most of the Agricultural strata correspond to SIC Major Groups 01 (Agricultural Production Crops), and 02 (Agricultural Production Livestock and Animal Specialties). The Farm Management stratum corresponded largely to SIC Industry Groups 017 (Soil Preparation Services), 072 (Crop Services), and 076 (Farm Labor and Management Services). The Construction and Mining strata correspond to SIC Division C (Construction). The Logging stratum corresponds to Industry Group 241 (Logging). The remainder of the Residual strata includes most/all of SIC Division D (Manufacturing), Division E (Transportation, Communications, Electric, Gas, and Sanitary Services), Division F (Wholesale Trade), Division G (Retail Trade), and a targeted subset of Divisions I (Services) and J (Public Administration) expected to utilize off-road equipment. SIC Division H (Finance, Insurance and Real Estate) was excluded from the sample frame selection, as little if any off-road equipment was expected in this sector.

The detailed crop type assignment for the Agriculture sector is presented in Appendix A. Appendix B lists the SIC groupings for each microstrata along with group descriptions.

Once the levels of stratification were established, the number of completed surveys, the total number of eligible respondents, and the total number of records in the sample frame were determined for each subsample type/microstratum. These values were then used to calculate proportions within each subsample type. Finally, the weights for each sample type (sample type 2) were calculated by dividing the proportion of records in the frame by the proportion of completed surveys, with the results shown in Table 28.[12]

Table 28. Relative Survey and Sample Size Proportions w/ Response Weightings

Sample Type 1	Sample Type 2	Microstrata	Completed Surveys	Proportion of Completed Surveys	Records in Frame	Proportion of Records in Frame	Weight
Agriculture	Nut Crop	N/A	62	0.208	1,830	0.134	0.644
Agriculture	Row Crop	N/A	80	0.268	2,507	0.183	0.682
Agriculture	Tree Fruit	N/A	13	0.044	3,568	0.261	5.983
Agriculture	Other	N/A	115	0.386	3,835	0.281	0.728
Agriculture	Farm Management	N/A	12	0.040	1,310	0.096	2.384
Agriculture	CAFO/Dairy	N/A	16	0.054	615	0.045	0.838
		Subtotal.	*298*		*13,665*		
Construction/Mining	Construction	Construction-a	52	0.225	30,392	0.333	1.479
Construction/Mining	Construction	Construction-b	20	0.087	4,235	0.046	0.531

[12] Small adjustments were applied to these weights depending upon the analysis of interest, to account for missing data fields. For example, when calculating average hp values within a sector, weights were recalculated as described above, but using only those records for which hp data were available.

Sample Type 1	Sample Type 2	Microstrata	Completed Surveys	Proportion of Completed Surveys	Records in Frame	Proportion of Records in Frame	Weight
Construction/Mining	Construction	Construction-c	159	0.688	56,575	0.620	0.901
		Subtotal.	*231*		*91,202*		
Construction/Mining	Mining	N/A	15	1	406	1	1.000
Residual/Logging	Logging	N/A	13	1	274	1	1.000
Residual/Logging	Residual	Residual-a	22	0.079	32,482	0.085	1.082
Residual/Logging	Residual	Residual-b	79	0.282	115,907	0.302	1.070
Residual/Logging	Residual	Residual-c	41	0.146	75,341	0.196	1.339
Residual/Logging	Residual	Residual-d	50	0.179	66,706	0.174	0.974
Residual/Logging	Residual	Residual-e	85	0.304	90,177	0.235	0.774
Residual/Logging	Residual	Residual-f	3	0.011	3,426	0.009	0.840
		Subtotal.	*280*		*384,039*		
Residential	Target	N/A	87	0.169	-	0.0337*	0.127
Residential	Other Residential	N/A	240	0.831	-	0.9663*	1.317
		Subtotal .	*327*		-		
		Total	**1,164**		**489,586**		

Note: The proportions for each shaded/non-shaded region sum to 1.

* Residential proportions derived from relative number of households in Target and Other Residential area counties.

These weights were applied to the data when conducting analyses at the sector level. Table 29 provides the resulting weighted frequency distribution by sample type.

Table 29. Weighted Survey Response Totals

Sample Type 1	Sample Type 2	Microstrata	Final Weight	Completed Surveys - Weighted
Agriculture	Nut Crop	N/A	0.644	40
Agriculture	Row Crop	N/A	0.682	55
Agriculture	Tree Fruit	N/A	5.983	78
Agriculture	Other	N/A	0.728	84
Agriculture	Farm Management	N/A	2.384	29
Agriculture	CAFO/Dairy	N/A	0.838	13
Construction/Mining	Construction	a	1.479	77
Construction/Mining	Construction	b	0.531	11
Construction/Mining	Construction	c	0.901	143
Construction/Mining	Mining	N/A	1	15
Residual/Logging	Logging	N/A	1	13
Residual/Logging	Residual	a	1.082	24
Residual/Logging	Residual	b	1.070	85
Residual/Logging	Residual	c	1.339	55
Residual/Logging	Residual	d	0.974	49
Residual/Logging	Residual	e	0.774	66
Residual/Logging	Residual	f	0.840	3
Residential	Target	N/A	0.127	11
Residential	Other Residential	N/A	1.317	316
			Total	**1,164***

* Summation (1,167) difference due to rounding error

3.1.5 Equipment Inventory Findings

The following provides descriptive statistics for a variety of survey parameters, including equipment and fuel type distributions, activity profiles and application types, and hp and model year distributions. The analysis excludes electric equipment from all but the equipment type distribution analysis. These profiles are provided at the sector level – a detailed statistical analysis is provided for the statewide equipment population as a whole in Section 4.

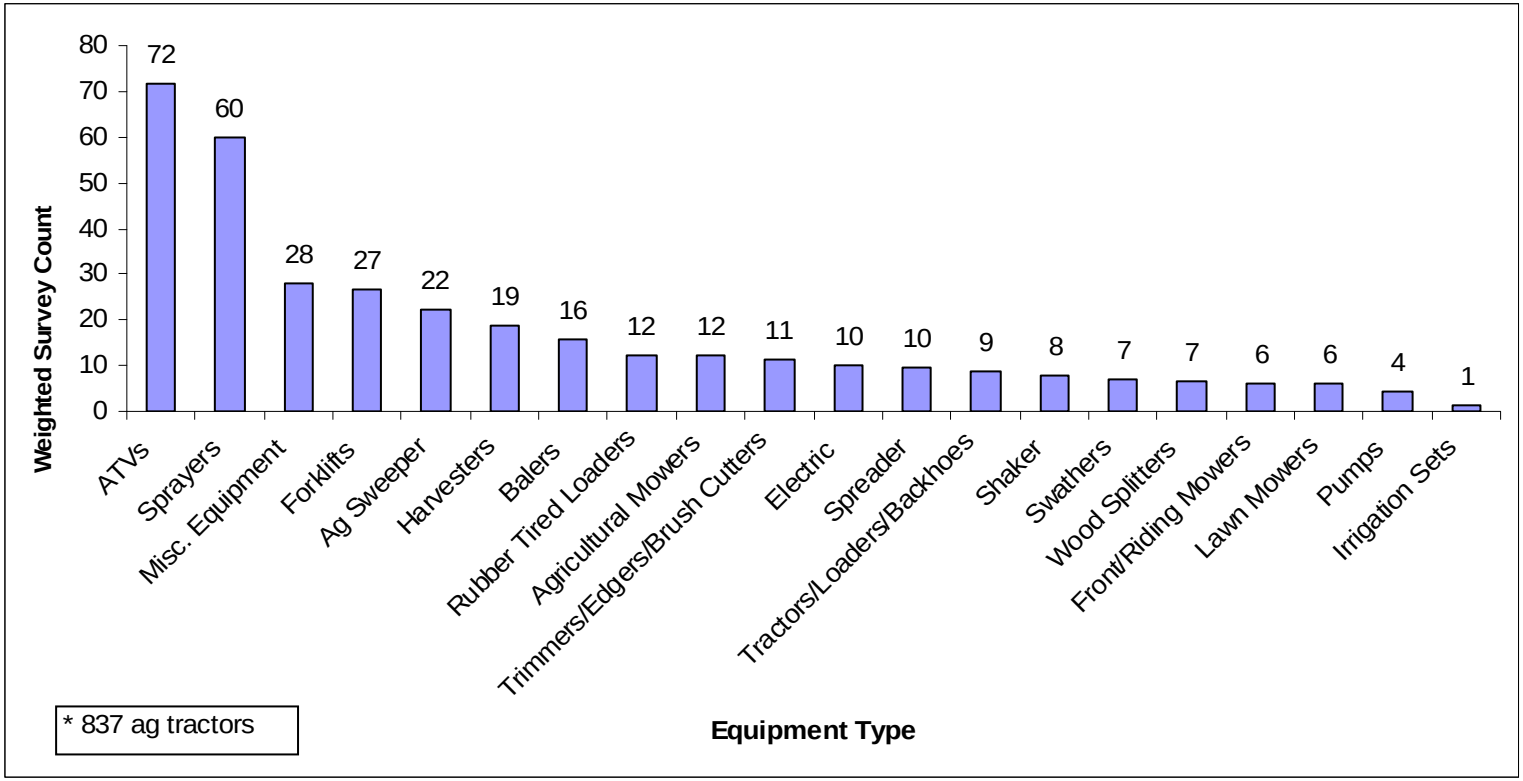
Equipment Type Distributions

Weighted equipment counts were tallied for each equipment type identified by survey respondents. For this summary, equipment types are not differentiated by fuel or application type. For example, lawn mowers are reported in the Agricultural Sector totals, although this equipment was almost exclusively designated as "personal/residential" use. Fuel type and application distributions are discussed separately below, and in more detail in the Preemption Analysis in Section 4.

The reported equipment type distribution within the Agricultural sector is presented in Figure 7. Forty two separate equipment types were reported altogether, for a total weighted equipment count of 1,183. Note that agricultural tractors were by far the most common piece of equipment reported, and are not presented in the figure due to scale considerations. Of the remaining equipment types, ATVs were the next most prevalent, followed closely by sprayers. Although with substantially lower totals, industrial equipment such as forklifts, construction equipment such as rubber tire loaders and tractor/loader/backhoes, and lawn and garden equipment such as trimmers and lawn mowers are fairly common as well. The Miscellaneous category included a wide variety of equipment types, none of which totaled more than three observations. These included generators sets, balancers, and tillers, among others, with 18 individual equipment categories included in all. The majority of the remaining units consisted of a number of specialty agricultural equipment. Miscellaneous equipment categories in this sector are listed below, along with their weighted population counts.

- Generator sets (3)
- Cranes (3)
- Tillers (3)
- Balancers (3)
- Yard trucks (2)
- Chainsaws (1)
- Trenchers (1)
- Welders (1)
- Excavators (1)
- Ag wells (1)
- Bale haulers (1)
- Crawler tractors (1)
- Skid steer loader (1)
- Aerial lifts (1)
- Leaf blower/vacuums (1)
- Shredders (1)
- Unknown "Caterpillar" (1)
- "Diesel Motor" (1)

Figure 7. Agricultural Sector Population Distribution (w/out tractors)*



N = 1,183 weighted units

The low number of pumps and irrigation sets reported in this sector was unexpected and may be indicative of under-reporting on the part of survey respondents rather than actual low population counts. Specifically, we suspect that respondents may not have considered these equipment types to be "off-road" even though agricultural pumps were explicitly included in the list of example equipment for this sector.

Figure 8 presents the weighted distribution of equipment types reported within the Construction and Mining sector. A broad range of reported equipment types are included, covering 42 categories, for a total of 641 weighted pieces of equipment. Electric equipment was by far the most common category at 188 pieces, and is excluded from the chart due to scale. Of the remaining equipment types, generator sets, air compressors, and tractor/loader/backhoes are ubiquitous within this sector. Although substantially less common, skid steer loaders and industrial forklifts are the next most common types.

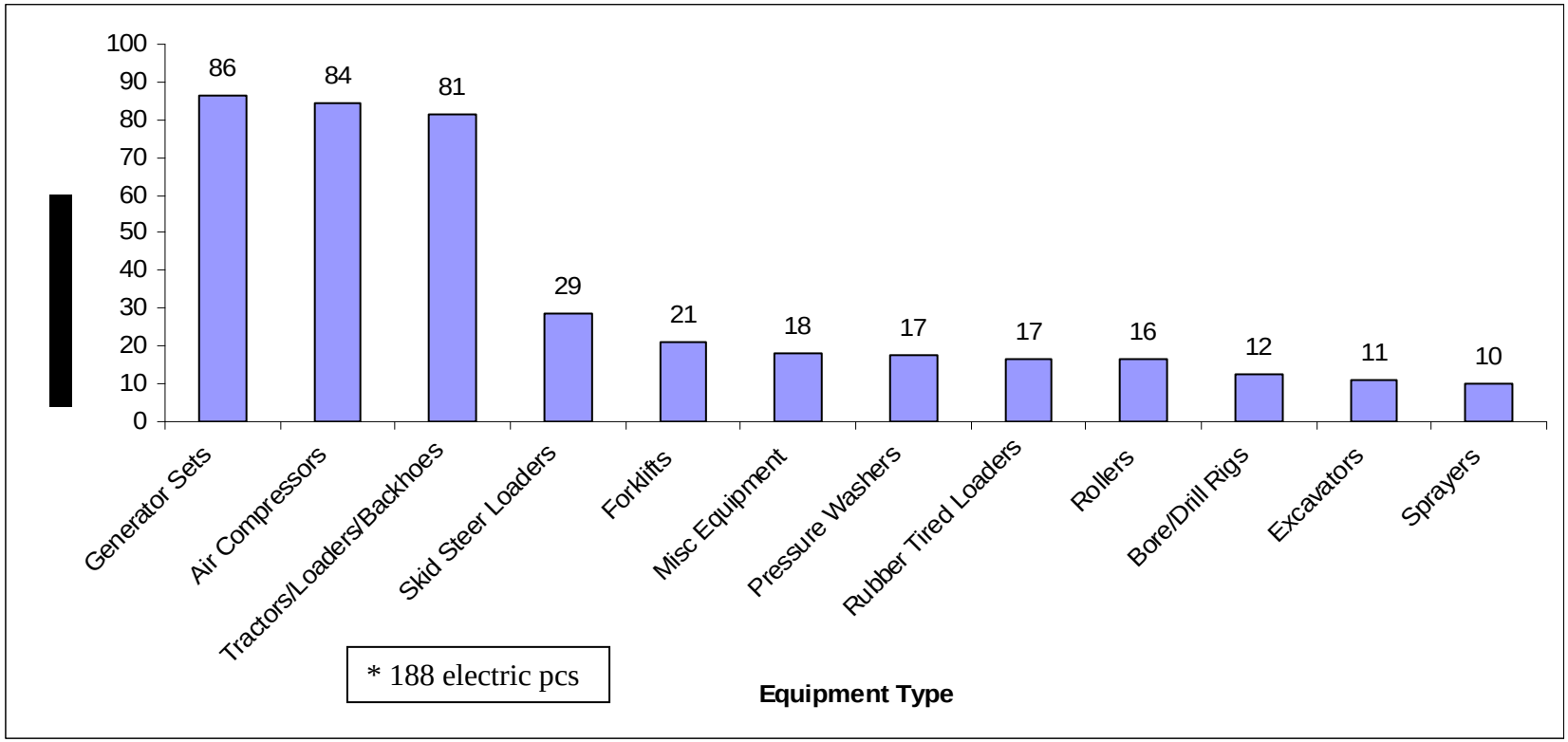
Heavier pieces of equipment such as excavators and crawler tractors/dozers are much less common in the Construction and Mining sector, perhaps because units less than 175 hp are relatively uncommon for these categories. The most common construction equipment categories are represented to some degree however, with the exception of rough terrain forklifts and surfacing equipment. Thirteen equipment categories were included in the Miscellaneous category, with none having greater than five observations. These included assorted lawn and garden equipment, unspecified vacuums, and various specialty equipment (e.g., pipe threaders). Miscellaneous equipment categories in this sector are listed below, along with their weighted population counts.

- Vacuums (5)
- Trimmers/edgers/brushcutters (3)
- Snowmobiles (3)
- Pipe threaders (2)
- Leaf blowers/vacuums (2)
- Champ (1)
- Hydro power units (1)
- Tillers (1)
- Vessels w/ outboard engines (1)
- Storm grinders (<1)
- Chippers/stump grinders (<1)
- Material handling - other (<1)
- Water truck (<1)

Figure 9 summarizes the equipment distribution reported for the Residential sector. This sector reported the lowest number of discrete equipment categories with 27. The total weighted equipment count for this sector came to 704 units. Lawn mowers, electric equipment, trimmers/edgers/brushcutters, and chainsaws were pervasive within this sector. Perhaps unexpected, agricultural tractors were reported with some frequency. Alternatively, certain types of recreational equipment were reported only infrequently (e.g., personal watercraft and minibikes). Miscellaneous equipment categories in this sector are listed below, along with their weighted population counts.

- "Yard burn" (1)
- Snowblowers (1)
- Cement & mortar mixers (<1)
- "Dirt remover" (<1)
- Graders (<1)
- Snowmobiles (<1)
- Sprayers (<1)

Figure 8. Construction and Mining Sector Population Distribution (w/out Electric Equipment*)



N = 641 weighted units

Figure 8. Construction and Mining Sector Population Distribution Continued

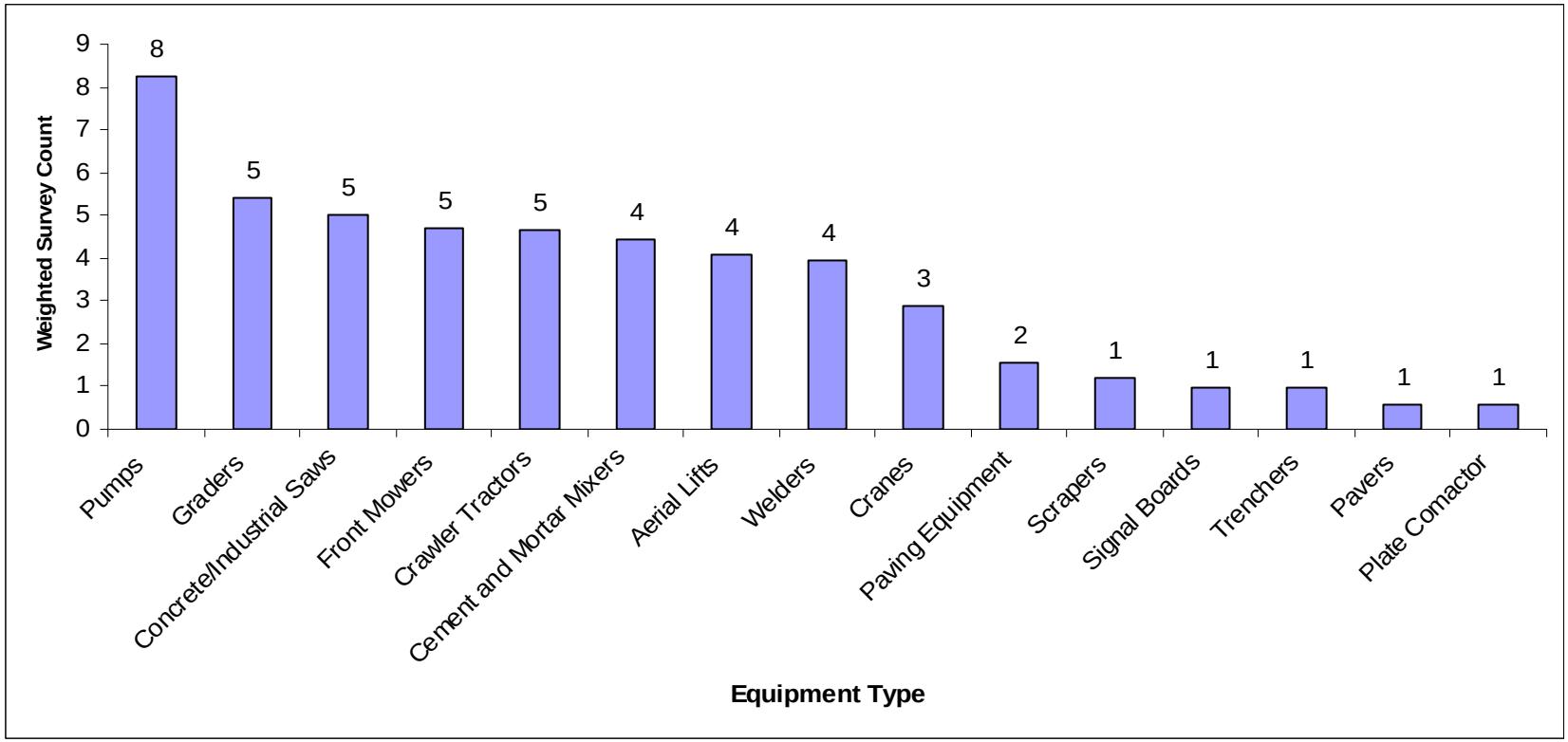
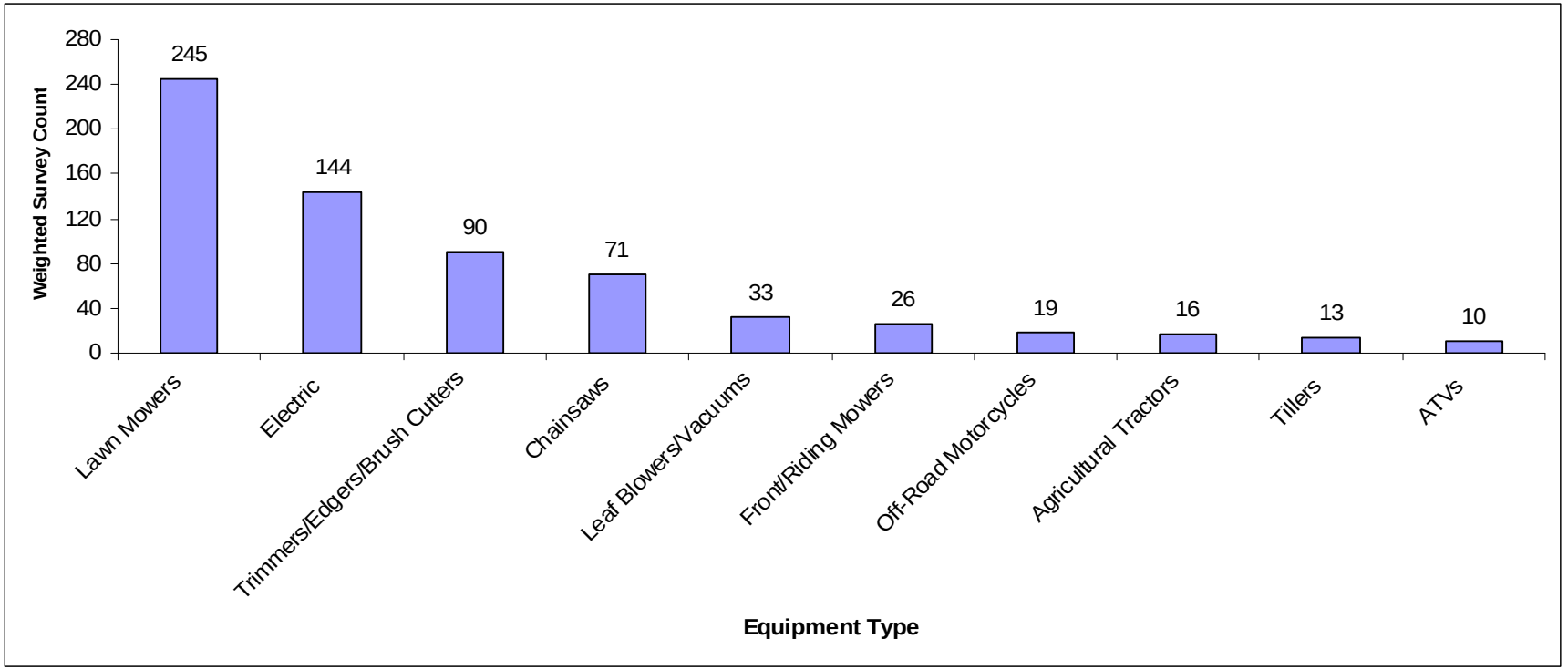


Figure 9. Residential Sector Equipment Population Distribution



N = 704 weighted units

Figure 9. Residential Sector Equipment Population Distribution Continued

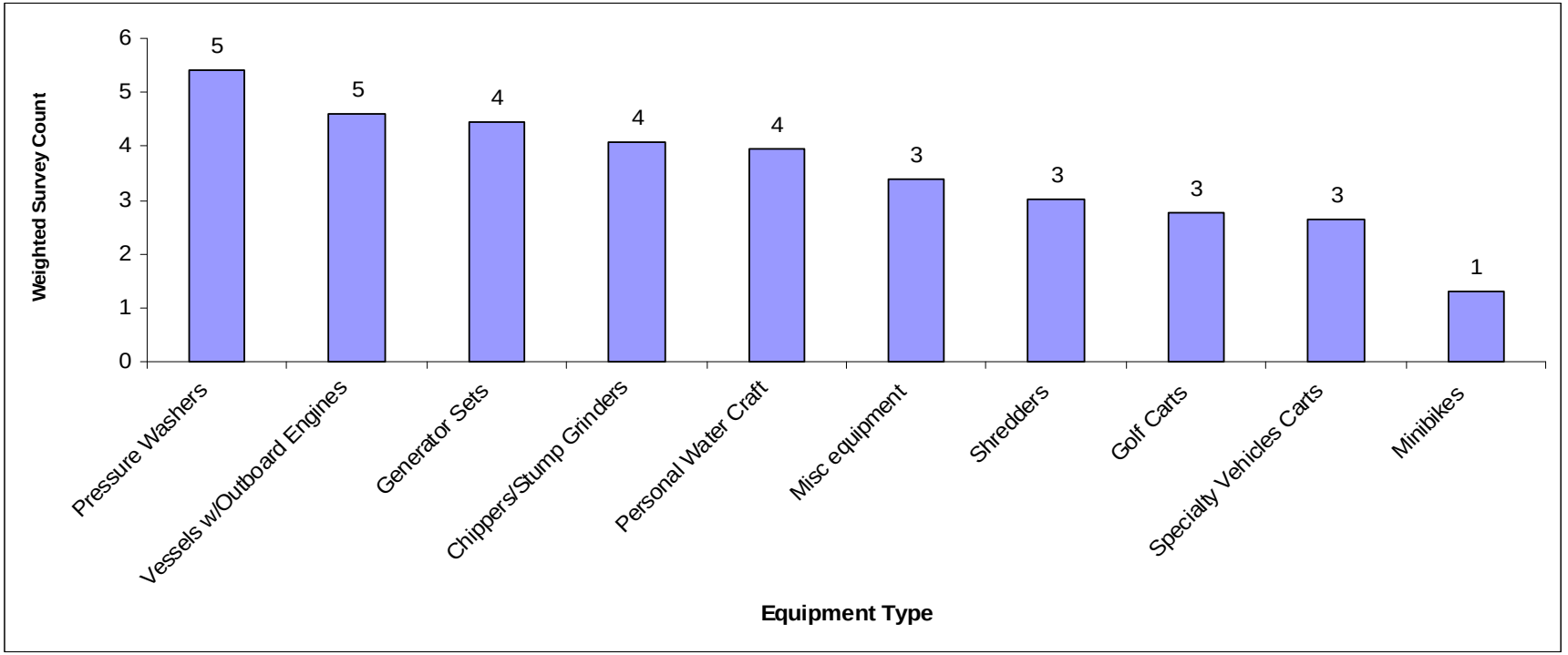


Figure 10 presents the equipment distribution for the Residual sector. This sector reported the greatest number of equipment types at 48, with 860 weighted units. This finding is not surprising since this sector covers the broadest range of applications (commercial, other than agricultural and construction/mining).

Electric equipment is by far the most common, followed by industrial forklifts. The high number of transportation refrigeration units (TRUs) appears to be an anomalous result, with all units being reported by a single respondent – no other TRUs were reported among any other respondent in any sector.

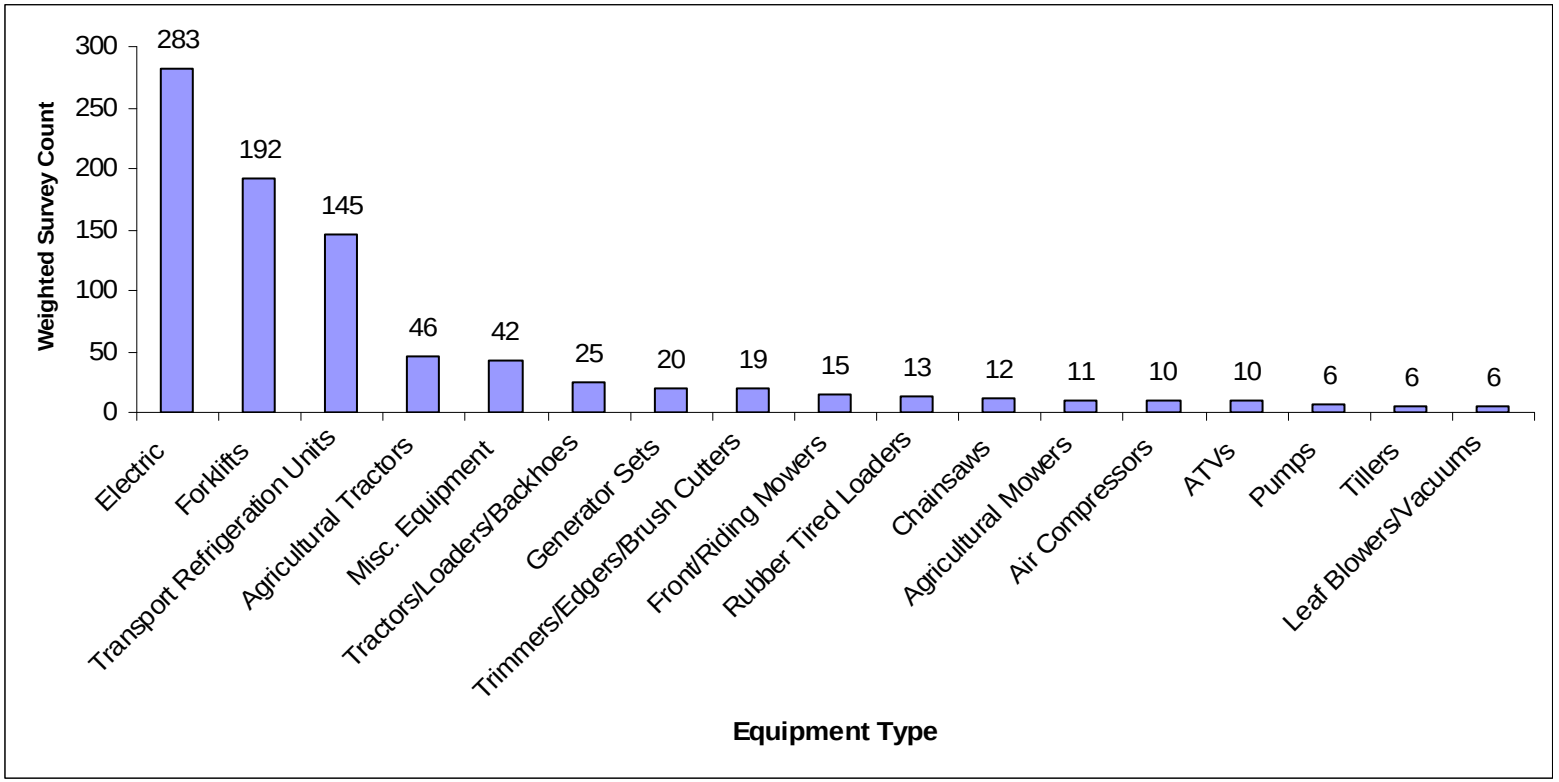
The remainder of the reported categories in the Residual sector consisted largely of various agricultural, construction, and lawn and garden equipment. The Miscellaneous category consisted of a very wide range of equipment types (31 total), with none having more than 3 observations. The following equipment types were included in the Miscellaneous category for this sector, along with their weighted populations.

- Car lift (3)
- Pressure washer (3)
- Golf cart (3)
- Welder (2)
- Chipper/Stump grinder (2)
- Skid steer loader (2)
- Personal watercraft (2)
- Lawn mower (2)
- Splice (1)
- Ag sweeper (1)
- Cart (1)
- "Feed Feeder" (1)
- Sprayer (1)
- Sweeper/Scrubber (1)
- Tamper/Rammer (1)
- Thatcher (1)
- Trencher (1)
- Chainsaw (1)
- Vacuum pot holer (1)
- Agricultural tractor (1)
- Front/Riding mower (1)
- Aerial lift (1)
- Alignment rack (1)
- Minibike (1)
- Snowblower (1)
- Tire balancer (1)
- Tire changer (1)
- Skidder (<1)
- Crawler (<1)
- Excavator (<1)
- Grader (<1)

While this sector reported a very diverse range of equipment categories, several specialty pieces of equipment were not identified (e.g., ground support equipment, or "GSE"), due to the overall rarity of such equipment, and the limited sample size in this sector.

A geographic breakdown was also prepared for the Agricultural sector, differentiating between equipment operated in the San Joaquin Valley (SJV) and other areas of the state. Table 30 summarizes the non-electric equipment categories and weighted equipment counts for all equipment reported by Agricultural sector respondents, broken out by production region. (Note that all equipment and fuel type data presented in this and subsequent tables refer to non-electric equipment, unless otherwise noted.)

Figure 10. Residual Sector Equipment Population Distribution



N = 860 weighted units

Table 30. Equipment Categories and Counts Reported by Agricultural Region

Region	Reported Equipment Categories	Weighted Equipment Count
SJV	26	639
Other Areas	31	534
Total	**42**	**1,173**

Fuel Type Distributions

Fuel type was specified for all but 35 pieces of equipment (~1% of non-electric equipment records). Fuel type assignments for these units were made allocating them proportionally among other units in the same equipment category. Fuel type distributions were calculated for the weighted equipment counts, by survey sector. Percentages are provided for gasoline, diesel, and compressed gas (including LPG and natural gas). All equipment categories are presented, regardless of the number of observations - a formal uncertainty analysis is performed for unique equipment/fuel type combination in Section 4.

Table 31 presents the weighted fuel type distributions for the Agricultural sector. Notably, 94% of agricultural tractors were diesel powered, with the remainder powered by gasoline. Similarly, most traditional agricultural equipment was predominantly diesel, including balers, combines, shakers, and swathers. Notable exceptions include agricultural mowers and sprayers, which are predominately gasoline powered. Gasoline engines were also predominant among lawn and garden equipment and generator sets. The majority of industrial forklifts were powered by compressed gas (specifically LPG), although significant numbers were also powered by gasoline and diesel as well. Some unusual equipment/fuel type combinations are also seen, including compressed gas spreaders and welders, although these distributions are likely not representative of the equipment population as a whole given the low observation count for these pieces.

Table 31. Weighted Fuel Type Distribution – Agricultural Sector

Equipment Type	Weighted Count	Compressed Gas	Diesel	Gasoline
Aerial Lifts	1	0%	0%	100%
Ag Wells	1	0%	100%	0%
Ag Sweeper	22	0%	94%	6%
Agricultural Mowers	12	0%	29%	71%
Agricultural Tractors	836	0%	94%	6%
All Terrain Vehicles	72	0%	10%	90%
Balancers	3	0%	100%	0%
Bale Haulers	1	0%	100%	0%
Balers	16	0%	95%	5%
Chainsaws	1	0%	0%	100%
Combines	19	7%	79%	14%
Cranes	3	0%	75%	25%
Crawler Tractors	1	0%	0%	100%
Diesel Motor	1	0%	100%	0%
Excavators	1	0%	53%	47%
Industrial Forklifts	27	54%	24%	22%
Front/Riding Mowers	6	0%	0%	100%

Equipment Type	Weighted Count	Compressed Gas	Diesel	Gasoline
Generator Sets	3	0%	48%	52%
Irrigation Sets	1	0%	100%	0%
Lawn Mowers	6	0%	0%	100%
Leaf Blowers/Vacuums	1	0%	0%	100%
Pruning Towers	1	0%	47%	53%
Pumps	4	0%	83%	17%
Rubber Tired Loaders	12	0%	84%	16%
Shakers	8	0%	100%	0%
Shredders	1	0%	0%	100%
Skid Steer Loaders	1	0%	100%	0%
Sprayers	60	0%	25%	75%
Spreader	10	100%	0%	0%
Swathers	7	0%	91%	9%
Tillers	3	0%	0%	100%
Tractors/Loaders/Backhoes	9	0%	100%	0%
Trenchers	1	0%	50%	50%
Trimmers/Edgers/Brush Cutters	11	0%	0%	100%
Unknown Caterpillar	1	0%	100%	0%
Welders	1	48%	0%	52%
Wood Splitters	7	0%	0%	100%
Yard Truck	2	0%	0%	100%
Total	**1,173**			

Table 32 presents the weighted fuel type distributions for the Construction and Mining sector. All of the larger construction equipment categories are dominated by diesel engines, including bore/drill rigs, cranes, crawler tractors, excavators, graders, loaders, rollers, skid steers, and backhoes. Gasoline engines are more common in smaller equipment, including air compressors, cement and mortar mixers, saws, generator sets, pressure washers, pumps, sprayers, and assorted lawn and garden equipment. Industrial forklifts were again predominately powered by LPG.

Table 32. Weighted Fuel Type Distribution – Construction/Mining Sector

Equipment Type	Weighted Count	Compressed Gas	Diesel	Gasoline
Aerial Lifts	4	38%	62%	0%
Air Compressors	84	2%	34%	63%
Bore/Drill Rigs	12	0%	77%	23%
Cement and Mortar Mixers	4	0%	35%	65%
Champ	1	0%	0%	100%
Chippers/Stump Grinders	<1	0%	100%	0%
Concrete/Industrial Saws	5	0%	0%	100%
Cranes	3	0%	100%	0%
Crawler Tractors	5	0%	98%	2%
Excavators	11	0%	100%	0%
Industrial forklifts	21	52%	36%	12%
Front/Riding Mowers	5	0%	0%	100%
Generator Sets	86	1%	6%	93%
Graders	5	0%	100%	0%

Equipment Type	Weighted Count	Compressed Gas	Diesel	Gasoline
Hydro Power Units	1	0%	0%	100%
Leaf Blowers/Vacuums	2	0%	0%	100%
Materials Handling (Other)	<1	0%	100%	0%
Pavers	1	0%	100%	0%
Paving Equipment	2	0%	0%	100%
Pipe Threader	2	0%	0%	100%
Plate Compactor	1	0%	100%	0%
Pressure Washers	17	0%	0%	100%
Pumps	8	0%	31%	69%
Rollers	16	0%	79%	21%
Rubber Tired Loaders	17	0%	100%	0%
Scrapers	1	0%	100%	0%
Signal Boards	1	0%	100%	0%
Skid Steer Loaders	29	0%	100%	0%
Snowmobiles	3	0%	0%	100%
Sprayers^	10	0%	9%	62%
Storm Grinders	<1	0%	50%	50%
Tillers	1	0%	0%	100%
Tractors/Loaders/Backhoes	81	1%	97%	1%
Trenchers	1	0%	0%	100%
Trimmers/Edgers/Brush Cutters	3	0%	0%	100%
Vacuum	5	0%	0%	100%
Vessels w/Outboard Engines	1	0%	0%	100%
Welders	4	0%	26%	74%
Total	**453**			

^ 28% reported as dual gas/electric

Table 33 presents the weighted fuel type distributions for the Residential sector. This sector is populated almost exclusively with gasoline powered equipment, with minor exceptions for ATVs and outboard engines.

Table 33. Weighted Fuel Type Distribution – Residential Sector

Equipment Type	Weighted Count	Compressed Gas	Diesel	Gasoline
Agricultural Tractors	16	0%	10%	90%
All Terrain Vehicles	10	0%	13%	87%
Cement and Mortar Mixers	<1	0%	0%	100%
Chainsaws	71	0%	0%	100%
Chippers/Stump Grinders	4	0%	0%	100%
Dirt Remover	<1	0%	0%	100%
Front/Riding Mowers	26	0%	0%	100%
Generator Sets	4	0%	0%	100%
Golf Carts	3	0%	0%	100%
Graders	<1	0%	100%	0%
Lawn Mowers	245	0%	0%	100%
Leaf Blowers/Vacuums	33	0%	0%	100%
Minibikes	1	0%	0%	100%
Off-Road Motorcycles	19	0%	0%	100%

Equipment Type	Weighted Count	Compressed Gas	Diesel	Gasoline
Personal Water Craft	4	0%	0%	100%
Pressure Washers	5	0%	0%	100%
Shredders	3	0%	0%	100%
Snowblowers	1	0%	0%	100%
Snowmobiles Active	<1	0%	0%	100%
Specialty Vehicles Carts	3	0%	0%	100%
Sprayers	<1	0%	0%	100%
Tillers	13	0%	0%	100%
Trimmers/Edgers/Brush Cutters	90	2%	0%	98%
Vessels w/Outboard Engines	5	0%	29%	71%
Yard Burn	1	0%	0%	100%
Total	**560**			

Table 34 presents the weighted fuel type distributions for the Residual sector. Among the equipment categories with significant observations, agricultural tractors, skidders, and heavy construction equipment accounted for most of the diesel engines. Gasoline engines predominated in agricultural mowers and other smaller equipment, including ATVs, generator sets, pumps, and lawn and garden equipment. Compressed gas was the predominant fuel type for industrial forklifts, with small contributions among air compressors and generator sets.

Table 34. Weighted Fuel Type Distribution – Residual Sector

Equipment Type	Weighted Count*	Compressed Gas	Diesel	Gasoline
Ag Sweepers	1	0%	100%	0%
Agricultural Mowers	11	0%	8%	92%
Agricultural Tractors	47	0%	93%	7%
Air Compressors	10	9%	17%	74%
All Terrain Vehicles	10	0%	14%	86%
Cart	1	0%	0%	100%
Chainsaws	13	0%	0%	100%
Chippers/Stump Grinders	2	0%	50%	50%
Crawler Tractors	<1	0%	100%	0%
Excavators	<1	0%	100%	0%
Feed Feeder	1	0%	0%	100%
Industrial forklifts^	192	75%	9%	16%
Front/Riding Mowers	16	0%	26%	74%
Generator Sets	20	4%	23%	73%
Golf Carts	3	0%	0%	100%
Graders	<1	0%	100%	0%
Lawn Mowers	2	0%	0%	100%
Leaf Blowers/Vacuums	6	0%	0%	100%
Minibikes	1	0%	0%	100%
Personal Water Craft	2	0%	0%	100%
Pressure Washers	3	0%	0%	100%
Pumps	6	0%	46%	54%
Rubber Tired Loaders	13	0%	92%	8%
Skid Steer Loaders	3	0%	100%	0%
Skidders	<1	0%	100%	0%

Equipment Type	Weighted Count*	Compressed Gas	Diesel	Gasoline
Snowblowers	1	0%	0%	100%
Splice	1	0%	100%	0%
Sprayers	1	0%	0%	100%
Sweepers/Scrubbers	1	0%	0%	100%
Tampers/Rammers	1	0%	0%	100%
Tillers	6	0%	0%	100%
Tractors/Loaders/Backhoes	25	0%	78%	22%
Transport Refrigeration Units	145	0%	0%	100%
Trenchers	1	0%	0%	100%
Trimmers/Edgers/Brush Cutters	19	0%	0%	100%
Welders	2	0%	0%	100%
Total	**570**			

* 1 aerial lift, 3 car lifts, 1 tire balancer and 1 tire changer had no fuel type reported, and are excluded from the table.

^ 1% reported "dual fuel – gasoline/propane"

Application Distributions

Survey respondents characterized the percent of time each piece of equipment was used for the following applications:

- Agricultural production, harvesting, or processing;
- Automotive;
- Building or construction;
- Industrial uses;
- Personal or residential;
- Recreational;
- Warehousing;
- Other, such as cleaning or maintenance (to be specified by respondent).

Application type distributions were provided for over 98% of non-electric equipment records. The following tables summarize the fraction of time attributed to each of the application types listed above for each sector, averaged across all equipment types. (A detailed analysis of applications at the equipment/fuel type level is presented in the Preemption Analysis in Section 4.) Note that no attempt was made to determine the cause of any apparent discrepancies (e.g., construction sector respondents reporting recreational equipment use), although such responses were confirmed during the survey call.

Summary tables were prepared for each sector using the equipment records with reported application type distributions. Table 35 presents the results for the Agricultural sector. Over 97% of all equipment activity in this sector is attributed to agricultural uses, with personal/residential uses having the next highest percentage. A small number of "other" applications included beekeeping and delivery activities.

Table 35. Application Type Distribution – Agricultural Sector, All Equipment

Use Category	Reported Utilization
Agricultural production, harvesting or processing	97.09%
Automotive	0.08%
Building or construction	0.23%
Other such as cleaning or maintenance	0.75%
Personal or residential	1.30%
Recreational	0.05%
Warehousing	0.51%

Table 36 presents the findings for the Construction and Mining sector. Although over 78% of all activity was identified as construction-related, non-trivial activity was also reported for the Other category, as well as industrial, agricultural, personal, and warehousing. "Other" category descriptions included pool cleaning, boat building, general painting, and delivery, among others.

Table 36. Application Type Distribution – Construction/Mining Sector, All Equipment

Use Category	Reported Utilization
Agricultural production, harvesting or processing	3.72%
Automotive	0.19%
Building or construction	78.56%
Industrial	3.80%
Other such as cleaning or maintenance	7.39%
Personal or residential	3.33%
Recreational	0.76%
Warehousing	2.24%

Table 37 presents the findings for the Residential sector. In this case almost 85% of all equipment use was deemed for personal or residential purposes. The next highest utilization was for recreational purposes, at ~8%. "Other" applications listed included fire protection and care of pastures. No responses were provided for industrial or warehousing applications.

Table 37. Application Type Distribution – Residential Sector, All Equipment

Use Category	Reported Utilization
Agricultural production, harvesting or processing	3.23%
Automotive	0.08%
Building or construction	1.41%
Other such as cleaning or maintenance	2.70%
Personal or residential	84.65%
Recreational	7.94%

Table 38 presents the findings for the Residual sector. This sector displayed the most diverse range of applications, as expected, with industrial applications having the highest percentage. Agricultural applications had the next highest percentage, followed closely by warehousing and "other" uses. "Other" applications were numerous (41 distinct descriptions), and included

characterizations (e.g., “commercial use”) as well as highly specific descriptions (e.g., grave digging).

Table 38. Application Type Distribution – Residual Sector, All Equipment

Use Category	Reported Utilization
Agricultural production, harvesting or processing	20.11%
Automotive	4.75%
Building or construction	3.55%
Industrial	35.01%
Other such as cleaning or maintenance	13.13%
Personal or residential	6.30%
Recreational	0.66%
Warehousing	16.49%

Seasonal Activity Distributions

Survey respondents estimated the percentage of time each piece of equipment was operated by season. Seasonal allocation estimates were provided for approximately 78% of all equipment records. For those records with seasonal distribution estimates, reported annual hours for each piece of equipment were allocated across the four seasons and summed across all non-electric equipment types to obtain total hours of activity by season for each sector. The final distributions are reported for each sector in Table 39.

Table 39. Seasonal Activity Distribution by Survey Sector

Sector	Winter	Spring	Summer	Fall
Agricultural	15%	28%	32%	25%
Construction & Mining	23%	25%	28%	24%
Residential	11%	29%	40%	21%
Residual	23%	26%	27%	24%

As anticipated, the Agricultural and Residential sectors experience their lowest activity levels in the winter and their highest levels in the summer, with the extremes more pronounced for the Residential sector. The activity distributions for the Residual and Construction/Mining sectors are effectively level across all four seasons.

Average Annual Activity

Annual activity for the 2007 calendar year was specified for 83% of non-electric equipment records. Annual activity averages were calculated using weighted equipment counts, by survey sector. All equipment categories are presented, regardless of the number of observations - a formal uncertainty analysis is performed for unique equipment/fuel type combinations in Section 4.

Table 40 presents the average hours per year for the Agricultural sector, along with the weighted number of units without a reported hour per year value. Diesel agricultural tractors had by far the highest number of observations, followed by gasoline powered ATVs and gasoline powered

tractors. Note that only 12 equipment/fuel type combinations had 10 or more weighted counts. Of these, only three equipment categories were estimated to operate more than about 500 hours per year in this sector (compressed gas forklifts, gasoline ATVs and rubber tire loaders). Table 41 presents the corresponding weighted activity distribution for equipment in this sector.

Table 40. Weighted Annual Average Hours/Year – Agricultural Sector

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	Average Hrs/Yr
Aerial Lifts	Gasoline	1	0	100
Ag Sweepers	Diesel	21	0	464
Ag Sweepers	Gasoline	1	0	38
Agricultural Mowers	Diesel	4	0	97
Agricultural Mowers	Gasoline	9	0	86
Agricultural Tractors	Compressed Gas	3	0	490
Agricultural Tractors	Diesel	774	9	391
Agricultural Tractors	Gasoline	50	0	160
All Terrain Vehicles	Diesel	7	0	576
All Terrain Vehicles	Gasoline	61	1	506
Balancers	Diesel	3	0	800
Bale Haulers	Diesel	1	0	300
Balers	Diesel	15	0	363
Balers	Gasoline	1	0	300
Chainsaws	Gasoline	1	0	45
Combines	Compressed Gas	1	0	100
Combines	Diesel	15	0	402
Combines	Gasoline	3	0	70
Cranes	Diesel	2	0	15
Cranes	Gasoline	1	0	15
Crawler Tractors	Gasoline	1	0	100
Excavators	Diesel	1	0	250
Excavators	Gasoline	<1	0	70
Industrial forklifts	Compressed Gas	15	0	700
Industrial forklifts	Diesel	6	0	961
Industrial forklifts	Gasoline	6	0	86
Generator Sets	Diesel	1	0	600
Generator Sets	Gasoline	2	0	15
Irrigation Sets	Diesel	1	0	1,400
Lawn Mowers	Gasoline	6	0	90
Leaf Blowers/Vacuums	Gasoline	1	0	3
Pruning Towers	Diesel	1	0	95
Pruning Towers	Gasoline	<1	0	180
Pumps	Diesel	3	0	226
Pumps	Gasoline	1	0	6
Rubber Tired Loaders	Diesel	10	0	1,161
Rubber Tired Loaders	Gasoline	2	0	75
Shakers	Diesel	7	0	355
Shredders	Gasoline	1	0	100

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	Average Hrs/Yr
Skid Steer Loaders	Diesel	1	0	200
Sprayers	Diesel	15	0	353
Sprayers	Gasoline	45	0	190
Spreaders	Compressed Gas	10	0	240
Swathers	Diesel	6	0	140
Swathers	Gasoline	1	0	35
Tillers	Gasoline	3	0	44
Tractors/Loaders/Backhoes	Diesel	9	0	144
Trenchers	Diesel	1	0	250
Trenchers	Gasoline	<1	0	1
Trimmers/Edgers/Brush Cutters	Gasoline	11	0	386
Welders	Gasoline	1	0	6
Wood Splitters	Gasoline	7	0	595

* Weighted counts only provided for equipment categories *with* hours per year.

Table 41. Weighted Equipment Activity Distribution – Agricultural Sector (Hr/Yr)

Equipment Type	Fuel Type	0 - 99	100 - 249	250 - 499	500 - 749	750 - 999	1000 - 1499	1500 - 1999	2000 - 2999	3000+
Aerial Lifts	Gasoline	0%	100%	0%	0%	0%	0%	0%	0%	0%
Ag Sweeper	Diesel	11%	5%	30%	38%	16%	0%	0%	0%	0%
Ag Sweeper	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Agricultural Mowers	Diesel	77%	23%	0%	0%	0%	0%	0%	0%	0%
Agricultural Mowers	Gasoline	24%	76%	0%	0%	0%	0%	0%	0%	0%
Agricultural Tractors	Comp. Gas	0%	52%	23%	0%	0%	0%	25%	0%	0%
Agricultural Tractors	Diesel	11%	29%	24%	29%	2%	3%	1%	1%	0%
Agricultural Tractors	Gasoline	54%	27%	4%	11%	4%	0%	0%	0%	0%
All Terrain Vehicles	Diesel	0%	10%	0%	79%	11%	0%	0%	0%	0%
All Terrain Vehicles	Gasoline	21%	16%	21%	20%	5%	10%	5%	3%	0%
Balancers	Diesel	0%	0%	0%	0%	100%	0%	0%	0%	0%
Bale Haulers	Diesel	0%	0%	100%	0%	0%	0%	0%	0%	0%
Balers	Diesel	10%	37%	24%	20%	5%	5%	0%	0%	0%
Balers	Gasoline	0%	0%	100%	0%	0%	0%	0%	0%	0%
Chainsaws	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Combines	Comp. Gas	0%	100%	0%	0%	0%	0%	0%	0%	0%
Combines	Diesel	4%	39%	24%	10%	13%	9%	0%	0%	0%
Combines	Gasoline	75%	0%	25%	0%	0%	0%	0%	0%	0%
Cranes	Diesel	100%	0%	0%	0%	0%	0%	0%	0%	0%
Cranes	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Crawler Tractors	Gasoline	0%	100%	0%	0%	0%	0%	0%	0%	0%
Excavators	Diesel	0%	0%	100%	0%	0%	0%	0%	0%	0%
Excavators	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Industrial forklifts	Comp. Gas	0%	9%	10%	10%	62%	4%	4%	0%	0%
Industrial forklifts	Diesel	11%	23%	11%	21%	11%	0%	0%	0%	23%
Industrial forklifts	Gasoline	88%	0%	12%	0%	0%	0%	0%	0%	0%
Generator Sets	Diesel	0%	0%	0%	100%	0%	0%	0%	0%	0%
Generator Sets	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Irrigation Sets	Diesel	0%	0%	0%	0%	50%	0%	0%	50%	0%
Lawn Mowers	Gasoline	62%	38%	0%	0%	0%	0%	0%	0%	0%
Leaf Blowers/Vacuums	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Pruning Towers	Diesel	100%	0%	0%	0%	0%	0%	0%	0%	0%

Equipment Type	Fuel Type	0 - 99	100 - 249	250 - 499	500 - 749	750 - 999	1000 - 1499	1500 - 1999	2000 - 2999	3000+
Pruning Towers	Gasoline	0%	100%	0%	0%	0%	0%	0%	0%	0%
Pumps	Diesel	21%	24%	55%	0%	0%	0%	0%	0%	0%
Pumps	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Rubber Tired Loaders	Diesel	0%	0%	0%	26%	0%	29%	45%	0%	0%
Rubber Tired Loaders	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Shakers	Diesel	9%	27%	27%	36%	0%	0%	0%	0%	0%
Shredders	Gasoline	0%	100%	0%	0%	0%	0%	0%	0%	0%
Skid Steer Loaders	Diesel	0%	100%	0%	0%	0%	0%	0%	0%	0%
Sprayers	Diesel	18%	9%	54%	10%	9%	0%	0%	0%	0%
Sprayers	Gasoline	41%	45%	7%	2%	0%	6%	0%	0%	0%
Spreader	Comp. Gas	0%	100%	0%	0%	0%	0%	0%	0%	0%
Swathers	Diesel	34%	54%	12%	0%	0%	0%	0%	0%	0%
Swathers	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Tillers	Gasoline	75%	25%	0%	0%	0%	0%	0%	0%	0%
Tractors/Loaders/Backhoes	Diesel	34%	43%	23%	0%	0%	0%	0%	0%	0%
Trenchers	Diesel	0%	0%	100%	0%	0%	0%	0%	0%	0%
Trenchers	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Trimmers/Edgers/Brush Cutters	Gasoline	42%	0%	0%	58%	0%	0%	0%	0%	0%
Welders	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Wood Splitters	Gasoline	11%	0%	0%	89%	0%	0%	0%	0%	0%

As a point of reference, a comparison was also made between activity in the SJV region and the rest of the state for diesel agricultural tractors, as shown in Table 42. As seen, activity levels are similar across regions.

Table 42. Average Annual Activity by Region for Diesel Agricultural Tractors

Region	Weighted Count*	Average Hrs/Yr
Diesel Ag. Tractors – SJV^	444	370
Diesel Ag. Tractors - Other areas^	330	418

* Weighted counts only provided for equipment categories *with* hours per year.
^ One SJV region observation with missing hr/yr response; eight missing hr/yr responses from other areas.

Table 43 presents the average hours per year for the Construction and Mining sector. Diesel backhoes and gasoline generator sets had the most observations, followed by gasoline air compressors and LPG industrial forklifts. Nine equipment/fuel type combinations had 10 or more weighted counts. Of these, diesel backhoes, diesel bore/drill rigs and compressed gas industrial forklifts averaged greater than 1,000 hours per year, while the remainder averaged approximately 600 hours per year or less. Table 44 provides the corresponding weighted activity distribution for this sector.

Table 45 presents the average hours per year for the Residential sector. Common lawn and garden equipment including lawn mowers, trimmers/edgers/brushcutters, chainsaws, and leaf blowers/vacuums had the highest number of observations. Eight equipment/fuel type combinations had 10 or more observations. Of these, all averaged less than 100 hours per year of activity. The corresponding activity distribution for this sector is presented in Table 46. From this table it is clear that the vast majority of all equipment use in this sector is less than 100 hours per year.

Table 43. Weighted Annual Average Hours/Year – Construction and Mining Sector

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	Average Hours/Year
Aerial Lifts	Compressed Gas	2	0	30
Aerial Lifts	Diesel	2	0	125
Air Compressors	Compressed Gas	2	0	550
Air Compressors	Diesel	25	3	658
Air Compressors	Gasoline	40	14	160
Bore/Drill Rigs	Diesel	10	0	1,600
Bore/Drill Rigs	Gasoline	2	0	150
Cement and Mortar Mixers	Diesel	2	0	1,560
Cement and Mortar Mixers	Gasoline	2	0	680
Chippers/Stump Grinders	Diesel	<1	0	46
Concrete/Industrial Saws	Gasoline	2	3	22
Cranes	Diesel	3	0	400
Crawler Tractors	Diesel	3	1	357
Crawler Tractors	Gasoline	<1	0	10
Excavators	Diesel	7	4	262
Industrial forklifts	Compressed Gas	10	0	1,276

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	Average Hours/Year
Industrial forklifts	Diesel	8	0	273
Industrial forklifts	Gasoline	3	0	182
Front/Riding Mowers	Gasoline	5	0	930
Generator Sets	Compressed Gas	1	0	2
Generator Sets	Diesel	4	1	136
Generator Sets	Gasoline	78	2	345
Graders	Diesel	2	3	275
Hydro Power Units	Gasoline	1	0	100
Leaf Blowers/Vacuums	Gasoline	2	0	50
Pavers	Diesel	1	0	100
Paving Equipment	Gasoline	2	0	20
Pipe Threader	Gasoline	2	0	1,560
Pressure Washers	Gasoline	13	4	384
Pumps	Diesel	3	0	281
Pumps	Gasoline	4	1	200
Rollers	Diesel	6	7	232
Rollers	Gasoline	3	0	187
Rubber Tired Loaders	Diesel	13	4	154
Scrapers	Diesel	1	0	837
Signal Boards	Diesel	1	0	60
Skid Steer Loaders	Diesel	19	10	439
Snowmobiles	Gasoline	3	0	5
Sprayers	Diesel	1	0	833
Sprayers	Dual Gasoline/Electric	3	0	1,000
Sprayers	Gasoline	6	0	645
Storm Grinder	Diesel	<1	0	20
Storm Grinder	Gasoline	<1	0	20
Tillers	Gasoline	1	0	1
Tractors/Loaders/Backhoes	Diesel	68	13	1,131
Tractors/Loaders/Backhoes	Gasoline	1	0	96
Trenchers	Gasoline	1	0	12
Trimmers/Edgers/Brush Cutters	Gasoline	<1	2	40
Vacuum	Gasoline	5	0	3,000
Vessels w/Outboard Engines	Gasoline	1	0	500
Welders	Diesel	1	0	107
Welders	Gasoline	3	0	188

* Weighted counts only provided for equipment categories *with* hours per year.

Table 44. Weighted Equipment Activity Distribution – Construction and Mining Sector (Hr/Yr)

Equipment Type	Fuel Type	0 - 99	100 - 249	250 - 499	500 - 749	750 - 999	1000 - 1499	1500 - 1999	2000 - 2999	3000 - 3999	4000+
Aerial Lifts	Comp. Gas	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Aerial Lifts	Diesel	62%	38%	0%	0%	0%	0%	0%	0%	0%	0%
Air Compressors	Comp. Gas	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
Air Compressors	Diesel	43%	19%	6%	0%	0%	0%	11%	21%	0%	0%
Air Compressors	Gasoline	34%	46%	15%	5%	0%	0%	0%	0%	0%	0%
Bore/Drill Rigs	Diesel	0%	0%	0%	0%	0%	50%	0%	50%	0%	0%
Bore/Drill Rigs	Gasoline	33%	67%	0%	0%	0%	0%	0%	0%	0%	0%
Cement and Mortar Mixers	Diesel	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
Cement and Mortar Mixers	Gasoline	33%	0%	0%	0%	0%	67%	0%	0%	0%	0%
Chippers/Stump Grinders	Diesel	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Concrete/Industrial Saws	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cranes	Diesel	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
Crawler Tractors	Diesel	63%	0%	0%	0%	37%	0%	0%	0%	0%	0%
Crawler Tractors	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Excavators	Diesel	52%	21%	6%	0%	20%	0%	0%	0%	0%	0%
Industrial forklifts	Comp. Gas	18%	40%	9%	0%	0%	9%	0%	16%	0%	9%
Industrial forklifts	Diesel	25%	13%	63%	0%	0%	0%	0%	0%	0%	0%
Industrial forklifts	Gasoline	62%	0%	38%	0%	0%	0%	0%	0%	0%	0%
Front/Riding Mowers	Gasoline	0%	33%	0%	0%	0%	67%	0%	0%	0%	0%
Generator Sets	Comp. Gas	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Generator Sets	Diesel	50%	25%	25%	0%	0%	0%	0%	0%	0%	0%
Generator Sets	Gasoline	52%	15%	15%	2%	1%	6%	0%	9%	0%	0%
Graders	Diesel	2%	78%	0%	0%	0%	20%	0%	0%	0%	0%
Hydro Power Units	Gasoline	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
Leaf Blowers/Vacuums	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Pavers	Diesel	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
Paving Equipment	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Pipe Threader	Gasoline	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
Pressure Washers	Gasoline	50%	25%	0%	0%	8%	0%	16%	0%	0%	0%
Pumps	Diesel	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
Pumps	Gasoline	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%

Equipment Type	Fuel Type	0 - 99	100 - 249	250 - 499	500 - 749	750 - 999	1000 - 1499	1500 - 1999	2000 - 2999	3000 - 3999	4000+
Rollers	Diesel	0%	89%	0%	0%	0%	11%	0%	0%	0%	0%
Rollers	Gasoline	17%	83%	0%	0%	0%	0%	0%	0%	0%	0%
Rubber Tired Loaders	Diesel	30%	53%	10%	7%	0%	0%	0%	0%	0%	0%
Scrapers	Diesel	0%	0%	6%	0%	94%	0%	0%	0%	0%	0%
Signal Boards	Diesel	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Skid Steer Loaders	Diesel	20%	35%	30%	0%	3%	0%	0%	12%	0%	0%
Snowmobiles	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sprayers	Diesel	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%
Sprayers	Dual Gas / electric	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%
Sprayers	Gasoline	15%	15%	0%	0%	45%	25%	0%	0%	0%	0%
Storm Grinder	Diesel	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Storm Grinder	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Tillers	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Tractors/Loaders/Backhoes	Diesel	13%	17%	7%	9%	0%	7%	5%	42%	0%	0%
Tractors/Loaders/Backhoes	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Trenchers	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Trimmers/Edgers/Brush Cutters	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Vacuum	Gasoline	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
Vessels w/Outboard Engines	Gasoline	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
Welders	Diesel	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
Welders	Gasoline	33%	35%	33%	0%	0%	0%	0%	0%	0%	0%

Table 45. Weighted Annual Average Hours/Year – Residential Sector

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	Average Hours/Year
Agricultural Tractors	Diesel	2	0	34
Agricultural Tractors	Gasoline	13	1	40
All Terrain Vehicles	Diesel	1	0	25
All Terrain Vehicles	Gasoline	9	0	89
Cement and Mortar Mixers	Gasoline	<1	0	10
Chainsaws	Gasoline	60	11	11
Chippers/Stump Grinders	Gasoline	3	1	12
Front/Riding Mowers	Gasoline	22	4	98
Generator Sets	Gasoline	4	0	34
Golf Carts	Gasoline	3	0	1,042
Graders	Diesel	<1	0	50
Lawn Mowers	Gasoline	212	33	50
Leaf Blowers/Vacuums	Gasoline	30	3	61
Off-Road Motorcycles	Gasoline	18	1	70
Personal Water Craft	Gasoline	4	0	12
Pressure Washers	Gasoline	4	1	44
Shredders	Gasoline	3	0	17
Snowblowers	Gasoline	1	0	11
Snowmobiles Active	Gasoline	<1	0	1
Specialty Vehicles Carts	Gasoline	1	2	100
Sprayers	Gasoline	<1	0	10
Tillers	Gasoline	11	2	84
Trimmers/Edgers/Brush Cutters	Compressed Gas	1	0	135
Trimmers/Edgers/Brush Cutters	Gasoline	70	19	41
Vessels w/Outboard Engines	Diesel	1	0	14
Vessels w/Outboard Engines	Gasoline	2	2	10

* Weighted counts only provided for equipment categories *with* hours per year.

Table 46. Weighted Equipment Activity Distribution – Residential Sector (Hr/Yr)

Equipment Type	Fuel Type	0 - 99	100 - 249	250 - 499	500 - 749	1000 - 1499
Agricultural Tractors	Diesel	100%	0%	0%	0%	0%
Agricultural Tractors	Gasoline	89%	10%	1%	0%	0%
All Terrain Vehicles	Diesel	100%	0%	0%	0%	0%
All Terrain Vehicles	Gasoline	51%	49%	0%	0%	0%
Cement and Mortar Mixers	Gasoline	100%	0%	0%	0%	0%
Chainsaws	Gasoline	99%	1%	0%	0%	0%
Chippers/Stump Grinders	Gasoline	100%	0%	0%	0%	0%
Front/Riding Mowers	Gasoline	93%	1%	0%	1%	6%
Generator Sets	Gasoline	100%	0%	0%	0%	0%
Golf Carts	Gasoline	5%	0%	0%	0%	95%
Graders	Diesel	100%	0%	0%	0%	0%
Lawn Mowers	Gasoline	95%	2%	1%	0%	2%
Leaf Blowers/Vacuums	Gasoline	91%	5%	0%	0%	4%
Off-Road Motorcycles	Gasoline	92%	0%	0%	8%	0%
Personal Water Craft	Gasoline	100%	0%	0%	0%	0%
Pressure Washers	Gasoline	100%	0%	0%	0%	0%
Shredders	Gasoline	100%	0%	0%	0%	0%
Snowblowers	Gasoline	100%	0%	0%	0%	0%
Snowmobiles	Gasoline	100%	0%	0%	0%	0%
Specialty Vehicles Carts	Gasoline	0%	100%	0%	0%	0%
Sprayers	Gasoline	100%	0%	0%	0%	0%
Tillers	Gasoline	75%	0%	25%	0%	0%
Trimmers/Edgers/Brush Cutters	Comp. Gas	9%	91%	0%	0%	0%
Trimmers/Edgers/Brush Cutters	Gasoline	94%	0%	6%	0%	0%
Vessels w/Outboard Engines	Diesel	100%	0%	0%	0%	0%
Vessels w/Outboard Engines	Gasoline	92%	8%	0%	0%	0%

Table 47 presents the average hours per year for the Residual sector. Gasoline TRUs and LPG industrial forklifts were by far the most common, followed by assorted agricultural, lawn and garden, construction, and general industrial equipment. Eleven equipment categories featured 10 or more observations. Of these, the gasoline TRUs had the highest average activity at 2,300 hours/year, followed by diesel backhoes and LPG industrial forklifts at 1,130 and 1,056 hours/ year, respectively. Of the remaining eight units with 10 or more observations, none exceeded 650 hours/year. Table 48 provides the corresponding activity distribution for this sector.

Table 47. Weighted Annual Average Hours/Year – Residual Sector

Equipment Type	Fuel Type	Weighted Count	Missing Obs. (Weighted)	Average Hr/Yr
Ag Sweepers	Diesel	1	0	50
Agricultural Mowers	Diesel	1	0	30
Agricultural Mowers	Gasoline	10	0	633
Agricultural Tractors	Diesel	33	11	477
Agricultural Tractors	Gasoline	3	0	452
Air Compressors	Compressed Gas	1	0	4
Air Compressors	Diesel	2	0	1,050
Air Compressors	Gasoline	6	1	86
All Terrain Vehicles	Diesel	1	0	200
All Terrain Vehicles	Gasoline	9	0	71
Chainsaws	Gasoline	9	4	135
Chippers/Stump Grinders	Diesel	1	0	30
Chippers/Stump Grinders	Gasoline	1	0	10
Crawler Tractors	Diesel	<1	0	604
Excavators	Diesel	<1	0	650
Industrial forklifts	Compressed Gas	127	19	1,056
Industrial forklifts	Diesel	11	5	491
Industrial forklifts	Dual Fuel Gas/Propane	1	0	12
Industrial forklifts	Gasoline	24	5	171
Front/Riding Mowers	Diesel	1	3	175
Front/Riding Mowers	Gasoline	11	1	200
Generator Sets	Compressed Gas	1	0	21
Generator Sets	Diesel	5	0	498
Generator Sets	Gasoline	13	1	189
Golf Carts	Gasoline	1	2	200
Graders	Diesel	<1	0	25
Lawn Mowers	Gasoline	2	0	65
Leaf Blowers/Vacuums	Gasoline	2	4	755
Minibikes	Gasoline	1	0	20
Personal Water Craft	Gasoline	2	0	10
Pressure Washers	Gasoline	2	1	33
Pumps	Diesel	2	0	488
Pumps	Gasoline	3	1	16
Rubber Tired Loaders	Diesel	11	1	476
Rubber Tired Loaders	Gasoline	1	0	288
Skid Steer Loaders	Diesel	3	0	1,000

Equipment Type	Fuel Type	Weighted Count	Missing Obs. (Weighted)	Average Hr/Yr
Skidders	Diesel	<1	0	817
Snowblowers	Gasoline	1	0	8
Tampers/Rammers	Gasoline	1	0	10
Tillers	Gasoline	6	0	74
Tractors/Loaders/Backhoes	Diesel	16	4	1,130
Tractors/Loaders/Backhoes	Gasoline	5	0	1,265
Transport Refrigeration Units	Gasoline	145	0	2,300
Trimmers/Edgers/Brush Cutters	Gasoline	19	0	194
Welders	Gasoline	1	1	20

* Weighted counts only provided for equipment categories *with* hours per year.

Table 48. Weighted Equipment Activity Distribution – Residual Sector (Hr/Yr)

Equipment Type	Fuel Type	0 - 99	100 - 249	250 - 499	500 - 749	750 - 999	1000 - 1499	1500 - 1999	2000 - 2999	3000+
Ag Sweeper	Diesel	100%	0%	0%	0%	0%	0%	0%	0%	0%
Agricultural Mowers	Diesel	100%	0%	0%	0%	0%	0%	0%	0%	0%
Agricultural Mowers	Gasoline	0%	0%	0%	83%	0%	17%	0%	0%	0%
Agricultural Tractors	Diesel	12%	18%	25%	14%	25%	3%	3%	0%	0%
Agricultural Tractors	Gasoline	0%	31%	34%	0%	34%	0%	0%	0%	0%
Air Compressors	Comp. Gas	100%	0%	0%	0%	0%	0%	0%	0%	0%
Air Compressors	Diesel	50%	0%	0%	0%	0%	0%	0%	50%	0%
Air Compressors	Gasoline	72%	16%	12%	0%	0%	0%	0%	0%	0%
All Terrain Vehicles	Diesel	0%	100%	0%	0%	0%	0%	0%	0%	0%
All Terrain Vehicles	Gasoline	45%	55%	0%	0%	0%	0%	0%	0%	0%
Chainsaws	Gasoline	48%	47%	5%	0%	0%	0%	0%	0%	0%
Chippers/Stump Grinders	Diesel	100%	0%	0%	0%	0%	0%	0%	0%	0%
Chippers/Stump Grinders	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Crawler Tractors	Diesel	20%	20%	20%	0%	0%	20%	20%	0%	0%
Excavators	Diesel	0%	0%	0%	50%	50%	0%	0%	0%	0%
Industrial forklifts	Comp. Gas	29%	7%	12%	3%	3%	10%	7%	29%	0%
Industrial forklifts	Diesel	0%	39%	39%	0%	14%	0%	0%	8%	0%
Industrial forklifts	Dual Gas / Propane	100%	0%	0%	0%	0%	0%	0%	0%	0%
Industrial forklifts	Gasoline	55%	11%	24%	7%	0%	4%	0%	0%	0%
Front/Riding Mowers	Diesel	50%	0%	50%	0%	0%	0%	0%	0%	0%
Front/Riding Mowers	Gasoline	38%	52%	0%	0%	0%	10%	0%	0%	0%
Generator Sets	Comp. Gas	100%	0%	0%	0%	0%	0%	0%	0%	0%
Generator Sets	Diesel	52%	0%	0%	0%	0%	48%	0%	0%	0%
Generator Sets	Gasoline	68%	16%	0%	0%	0%	16%	0%	0%	0%
Golf Carts	Gasoline	0%	100%	0%	0%	0%	0%	0%	0%	0%
Graders	Diesel	100%	0%	0%	0%	0%	0%	0%	0%	0%
Lawn Mowers	Gasoline	42%	58%	0%	0%	0%	0%	0%	0%	0%
Leaf Blowers/Vacuums	Gasoline	25%	0%	0%	0%	0%	75%	0%	0%	0%
Minibikes	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Personal Water Craft	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%

Equipment Type	Fuel Type	0 - 99	100 - 249	250 - 499	500 - 749	750 - 999	1000 - 1499	1500 - 1999	2000 - 2999	3000+
Pressure Washers	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Pumps	Diesel	0%	0%	50%	50%	0%	0%	0%	0%	0%
Pumps	Gasoline	98%	2%	0%	0%	0%	0%	0%	0%	0%
Rubber Tired Loaders	Diesel	0%	63%	0%	0%	0%	37%	0%	0%	0%
Rubber Tired Loaders	Gasoline	0%	0%	100%	0%	0%	0%	0%	0%	0%
Skid Steer Loaders	Diesel	0%	0%	0%	0%	0%	100%	0%	0%	0%
Skidders	Diesel	20%	0%	0%	0%	0%	80%	0%	0%	0%
Snowblowers	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Tampers/Rammers	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%
Tillers	Gasoline	60%	40%	0%	0%	0%	0%	0%	0%	0%
Tractors/Loaders/Backhoes	Diesel	13%	21%	0%	0%	0%	24%	0%	43%	0%
Tractors/Loaders/Backhoes	Gasoline	37%	0%	0%	0%	0%	0%	0%	63%	0%
Transport Refrigeration Units	Gasoline	0%	0%	0%	0%	0%	0%	0%	100%	0%
Trimmers/Edgers/Brush Cutters	Gasoline	20%	63%	12%	0%	0%	6%	0%	0%	0%
Welders	Gasoline	100%	0%	0%	0%	0%	0%	0%	0%	0%

Horsepower Distribution

The majority of respondents provided either a direct estimate of engine hp, or an estimated range corresponding to one of the following ranges:

- < 11 (5.5)
- 11 – 24 (17.5)
- 25 – 49 (37)
- 50 – 74 (62)
- 75 – 119 (97)
- 120 – 174 (147)

For this analysis point estimates were derived from the hp bins by taking the midpoint of the range, shown in parentheses above.

For many of those equipment records without a hp estimate, ERG was able to identify a hp value based on equipment make, model, and model year data provided by the respondent. After gap filling in this manner, approximately 89% of all equipment records were assigned a hp estimate.

Weighted population counts were tallied for equipment/fuel type combinations within each sector to estimate average hp values as well as distributions across the different hp bins. However, due to limited sample sizes and granularity in the data, only those equipment categories with the largest number of observations may accurately represent the population's true hp distribution. A more detailed evaluation of average hp for the statewide fleet is included in Section 4, including quality assurance assessments.

Tables 49 thru 52 present the hp distributions for the Agricultural, Construction and Mining, Residential, and Residual sectors, respectively.

Table 49. Weighted Equipment HP Distribution – Agricultural Sector

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	HP Bin					
				<11	11 - 24	25 - 49	50 - 74	75 - 119	120 - 174
Aerial Lifts	Gasoline	1	0	0%	0%	100%	0%	0%	0%
Ag Sweepers	Diesel	19	2	4%	0%	93%	0%	3%	0%
Ag Sweepers	Gasoline	1	0	0%	0%	100%	0%	0%	0%
Agricultural Mowers	Diesel	4	0	18%	0%	0%	82%	0%	0%
Agricultural Mowers	Gasoline	9	0	16%	84%	0%	0%	0%	0%
Agricultural Tractors	Comp. Gas	3	0	0%	0%	52%	23%	25%	0%
Agricultural Tractors	Diesel	747	36	0%	6%	23%	38%	25%	7%
Agricultural Tractors	Gasoline	47	3	5%	26%	41%	24%	3%	1%
All Terrain Vehicles	Diesel	3	4	0%	78%	11%	0%	11%	0%
All Terrain Vehicles	Gasoline	44	18	34%	45%	12%	5%	4%	0%
Balancers	Diesel	3	0	0%	0%	0%	0%	100%	0%
Bale Haulers	Diesel	1	0	0%	0%	0%	100%	0%	0%
Balers	Diesel	9	6	0%	0%	0%	78%	5%	17%
Balers	Gasoline	1	0	0%	0%	0%	100%	0%	0%
Chainsaws	Gasoline	1	0	100%	0%	0%	0%	0%	0%
Combines	Diesel	15	0	4%	5%	0%	40%	19%	32%
Combines	Gasoline	1	2	0%	0%	0%	100%	0%	0%
Crawler Tractors	Gasoline	1	0	100%	0%	0%	0%	0%	0%
Excavators	Diesel	1	0	0%	0%	0%	100%	0%	0%
Excavators	Gasoline	1	0	0%	0%	100%	0%	0%	0%
Industrial forklifts	Comp. Gas	12	3	0%	0%	28%	61%	11%	0%
Industrial forklifts	Diesel	5	1	0%	0%	42%	16%	16%	26%
Industrial forklifts	Gasoline	5	1	0%	0%	25%	22%	53%	0%
Generator Sets	Gasoline	2	0	100%	0%	0%	0%	0%	0%
Irrigation Sets	Diesel	1	0	0%	0%	0%	0%	50%	50%
Lawn Mowers	Gasoline	6	0	60%	40%	0%	0%	0%	0%
Leaf Blowers/Vacuums	Gasoline	1	0	100%	0%	0%	0%	0%	0%
Pruning Towers	Diesel	1	0	0%	0%	0%	100%	0%	0%
Pruning Towers	Gasoline	1	0	0%	100%	0%	0%	0%	0%
Pumps	Diesel	3	0	0%	21%	0%	18%	0%	61%
Pumps	Gasoline	1	0	100%	0%	0%	0%	0%	0%

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	HP Bin					
				<11	11 - 24	25 - 49	50 - 74	75 - 119	120 - 174
Rubber Tired Loaders	Diesel	11	0	0%	0%	7%	12%	52%	29%
Rubber Tired Loaders	Gasoline	2	0	0%	33%	67%	0%	0%	0%
Shakers	Diesel	7	0	0%	0%	0%	9%	82%	9%
Shredders	Gasoline	1	0	100%	0%	0%	0%	0%	0%
Skid Steer Loaders	Diesel	1	0	0%	0%	100%	0%	0%	0%
Sprayers	Diesel	13	2	0%	5%	12%	6%	66%	11%
Sprayers	Gasoline	40	5	25%	58%	0%	0%	7%	10%
Spreaders	Comp. Gas	10	0	0%	0%	0%	0%	100%	0%
Swathers	Diesel	3	3	0%	0%	0%	0%	60%	40%
Tillers	Gasoline	2	1	100%	0%	0%	0%	0%	0%
Tractors/Loaders/Backhoes	Diesel	9	0	0%	0%	36%	16%	40%	8%
Trenchers	Diesel	1	0	0%	0%	0%	100%	0%	0%
Trenchers	Gasoline	1	0	100%	0%	0%	0%	0%	0%
Trimmers/Edgers/Brush Cutters	Gasoline	11	0	100%	0%	0%	0%	0%	0%
Welders	Comp. Gas	1	0	0%	100%	0%	0%	0%	0%
Welders	Gasoline	1	0	0%	100%	0%	0%	0%	0%
Wood Splitters	Gasoline	7	0	100%	0%	0%	0%	0%	0%

* Weighted counts only provided for equipment categories *with* hp

Table 50. Weighted Equipment HP Distribution – Construction and Mining Sector

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	HP Bin					
				< 11	11 - 24	25 - 49	50 - 74	75 - 119	120 - 174
Aerial Lifts	Comp. Gas	2	0	0%	0%	100%	0%	0%	0%
Aerial Lifts	Diesel	1	1	100%	0%	0%	0%	0%	0%
Air Compressors	Diesel	27	1	17%	25%	43%	8%	7%	0%
Air Compressors	Gasoline	49	5	73%	11%	0%	12%	4%	0%
Bore/Drill Rigs	Diesel	10	0	0%	0%	0%	0%	40%	60%
Bore/Drill Rigs	Gasoline	2	0	0%	50%	0%	0%	0%	50%
Cement and Mortar Mixers	Diesel	2	0	100%	0%	0%	0%	0%	0%
Cement and Mortar Mixers	Gasoline	2	0	100%	0%	0%	0%	0%	0%
Chippers/Stump Grinders	Diesel	<1	0	0%	0%	0%	0%	0%	100%
Concrete/Industrial Saws	Gasoline	2	3	80%	20%	0%	0%	0%	0%
Cranes	Diesel	3	0	0%	0%	0%	0%	0%	100%
Crawler Tractors	Diesel	4	0	0%	0%	0%	0%	21%	79%
Crawler Tractors	Gasoline	<1	0	0%	0%	100%	0%	0%	0%
Excavators	Diesel	11	0	20%	0%	14%	14%	19%	33%
Industrial forklifts	Comp. Gas	6	4	0%	0%	35%	16%	23%	25%
Industrial forklifts	Diesel	3	5	33%	0%	0%	0%	67%	0%
Industrial forklifts	Gasoline	3	0	0%	0%	0%	0%	100%	0%
Front/Riding Mowers	Gasoline	5	0	0%	100%	0%	0%	0%	0%
Generator Sets	Comp. Gas	1	0	100%	0%	0%	0%	0%	0%
Generator Sets	Diesel	4	1	50%	0%	25%	25%	0%	0%
Generator Sets	Gasoline	76	4	61%	20%	1%	14%	3%	0%
Graders	Diesel	5	0	0%	0%	0%	11%	42%	47%
Hydro Power Units	Gasoline	1	0	0%	100%	0%	0%	0%	0%
Leaf Blowers/Vacuums	Gasoline	2	0	100%	0%	0%	0%	0%	0%
Materials Handling (Other)	Diesel	<1	0	0%	0%	0%	0%	100%	0%
Pavers	Diesel	1	0	0%	0%	0%	100%	0%	0%
Paving Equipment	Gasoline	2	0	100%	0%	0%	0%	0%	0%
Pipe Threader	Gasoline	2	0	100%	0%	0%	0%	0%	0%
Plate Compactor	Diesel	1	0	0%	0%	0%	0%	100%	0%
Pressure Washers	Gasoline	17	0	71%	23%	6%	0%	0%	0%
Pumps	Diesel	3	0	0%	0%	38%	62%	0%	0%

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	HP Bin					
				< 11	11 - 24	25 - 49	50 - 74	75 - 119	120 - 174
Pumps	Gasoline	5	0	100%	0%	0%	0%	0%	0%
Rollers	Diesel	13	0	0%	13%	65%	7%	7%	7%
Rollers	Gasoline	3	0	100%	0%	0%	0%	0%	0%
Rubber Tired Loaders	Diesel	13	4	0%	0%	6%	44%	39%	11%
Scrapers	Diesel	1	0	0%	0%	0%	0%	6%	94%
Signal Boards	Diesel	1	0	0%	0%	0%	100%	0%	0%
Skid Steer Loaders	Diesel	21	8	0%	0%	23%	31%	46%	0%
Snowmobiles	Gasoline	3	0	0%	0%	100%	0%	0%	0%
Sprayers	Diesel	1	0	0%	0%	100%	0%	0%	0%
Sprayers	Gasoline	6	0	40%	15%	45%	0%	0%	0%
Storm Grinder	Diesel	<1	0	0%	0%	100%	0%	0%	0%
Storm Grinder	Gasoline	<1	0	0%	0%	100%	0%	0%	0%
Tillers	Gasoline	1	0	100%	0%	0%	0%	0%	0%
Tractors/Loaders/Backhoes	Diesel	75	6	0%	4%	31%	20%	45%	0%
Tractors/Loaders/Backhoes	Gasoline	1	0	0%	0%	100%	0%	0%	0%
Trenchers	Gasoline	1	0	100%	0%	0%	0%	0%	0%
Trimmers/Edgers/Brush Cutters	Gasoline	3	0	100%	0%	0%	0%	0%	0%
Vacuum	Gasoline	5	0	0%	100%	0%	0%	0%	0%
Vessels w/Outboard Engines	Gasoline	1	0	100%	0%	0%	0%	0%	0%
Welders	Diesel	1	0	0%	7%	0%	0%	93%	0%
Welders	Gasoline	3	0	0%	65%	33%	0%	2%	0%

* Weighted counts only provided for equipment categories *with* hp

Table 51. Weighted Equipment HP Distribution – Residential Sector

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	HP Bin					
				< 11	11 - 24	25 - 49	50 - 74	75 - 119	120 - 174
Agricultural Tractors	Diesel	2	1	0%	50%	50%	0%	0%	0%
Agricultural Tractors	Gasoline	13	0	9%	54%	29%	0%	0%	7%
All Terrain Vehicles	Diesel	1	0	0%	100%	0%	0%	0%	0%
All Terrain Vehicles	Gasoline	6	3	23%	26%	23%	3%	3%	23%
Cement and Mortar Mixers	Gasoline	<1	0	100%	0%	0%	0%	0%	0%
Chainsaws	Gasoline	49	22	100%	0%	0%	0%	0%	0%
Chippers/Stump Grinders	Gasoline	3	1	52%	48%	0%	0%	0%	0%
Front/Riding Mowers	Gasoline	22	4	31%	62%	7%	0%	0%	0%
Generator Sets	Gasoline	4	0	89%	11%	0%	0%	0%	0%
Graders	Diesel	<1	0	0%	0%	0%	0%	100%	0%
Lawn Mowers	Gasoline	201	44	99%	1%	0%	0%	0%	0%
Leaf Blowers/Vacuums	Gasoline	27	6	80%	5%	5%	0%	10%	0%
Minibikes	Gasoline	1	0	0%	100%	0%	0%	0%	0%
Off-Road Motorcycles	Gasoline	13	6	1%	1%	65%	23%	0%	11%
Personal Water Craft	Gasoline	3	1	0%	0%	0%	0%	0%	100%
Pressure Washers	Gasoline	5	0	76%	24%	0%	0%	0%	0%
Shredders	Gasoline	3	0	100%	0%	0%	0%	0%	0%
Snowblowers	Gasoline	1	0	100%	0%	0%	0%	0%	0%
Snowmobiles	Gasoline	<1	0	0%	0%	100%	0%	0%	0%
Specialty Vehicles Carts	Gasoline	3	0	50%	0%	0%	0%	0%	50%
Sprayers	Gasoline	<1	0	100%	0%	0%	0%	0%	0%
Tillers	Gasoline	12	1	100%	0%	0%	0%	0%	0%
Trimmers/Edgers/Brush Cutters	Gasoline	67	23	92%	8%	0%	0%	0%	0%
Vessels w/Outboard Engines	Diesel	1	0	100%	0%	0%	0%	0%	0%
Vessels w/Outboard Engines	Gasoline	2	3	5%	0%	90%	5%	0%	0%

* Weighted counts only provided for equipment categories *with* hp

Table 52. Weighted Equipment HP Distribution – Residual Sector

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	HP Bin					
				< 11	11 - 24	25 - 49	50 - 74	75 - 119	120 - 174
Agricultural Mowers	Diesel	1	0	0%	100%	0%	0%	0%	0%
Agricultural Mowers	Gasoline	10	0	0%	17%	83%	0%	0%	0%
Agricultural Tractors	Diesel	40	4	0%	3%	12%	26%	34%	25%
Agricultural Tractors	Gasoline	3	0	0%	34%	66%	0%	0%	0%
Chainsaws	Gasoline	12	1	100%	0%	0%	0%	0%	0%
Industrial forklifts	Comp. Gas	124	22	5%	11%	21%	40%	9%	15%
Industrial forklifts	Diesel	16	0	0%	5%	41%	34%	0%	20%
Industrial forklifts	Gasoline	23	6	0%	10%	13%	32%	35%	10%
Front/Riding Mowers	Diesel	4	0	0%	58%	42%	0%	0%	0%
Front/Riding Mowers	Gasoline	11	1	37%	49%	14%	0%	0%	0%
Generator Sets	Comp. Gas	1	0	100%	0%	0%	0%	0%	0%
Generator Sets	Diesel	5	0	30%	24%	0%	0%	46%	0%
Generator Sets	Gasoline	14	0	69%	23%	8%	0%	0%	0%
Rubber Tired Loaders	Diesel	12	0	0%	0%	17%	18%	55%	10%
Rubber Tired Loaders	Gasoline	1	0	0%	0%	100%	0%	0%	0%
Tractors/Loaders/Backhoes	Diesel	18	2	0%	13%	58%	6%	23%	0%
Tractors/Loaders/Backhoes	Gasoline	5	0	0%	84%	0%	16%	0%	0%
Transport Refrigeration Units	Gasoline	145	0	0%	0%	0%	100%	0%	0%
Trimmers/Edgers/Brush Cutters	Gasoline	19	0	100%	0%	0%	0%	0%	0%

* Weighted counts only provided for equipment categories *with* hp

Model Year Distributions

Model years were provided by survey respondents for roughly one half of the non-electric equipment records. ERG was able to identify additional model year estimates for many units based on reported make and model from vendor references. In these cases ERG assigned model year based on the midpoint of the manufacturing period range. Once gap filling was complete 65% of all equipment records had a model year assignment.

Nevertheless, the majority of equipment categories did not have enough observations to provide a meaningful model year distributions. Therefore model year distributions were only developed for selected equipment/fuel type combinations, using weighted equipment counts for each sector. The model year bins presented in the tables below vary by equipment category in order to illustrate the distribution in the most appropriate fashion. However, with the possible exception of diesel agricultural tractors, the data sets for even these equipment categories are relatively thin, and data smoothing would be needed in order to estimate actual distributions for use in the OFFROAD model.

Table 53 presents the model year distribution for the most prevalent equipment/fuel type combinations in the Agricultural sector. Both gasoline and diesel agricultural tractors are heavily weighted toward the oldest model year bin. Gasoline sprayers also appear to be substantially weighted toward the older model year bins. Diesel combines and balers, on the other hand, appear to be more uniformly distributed across the range of model years.[13] Finally, gasoline powered ATVs tended to have the newest model year distribution, which may reflect their increasing popularity in agricultural applications.

Table 53. Model Year Distribution for Selected Equipment – Agricultural Sector

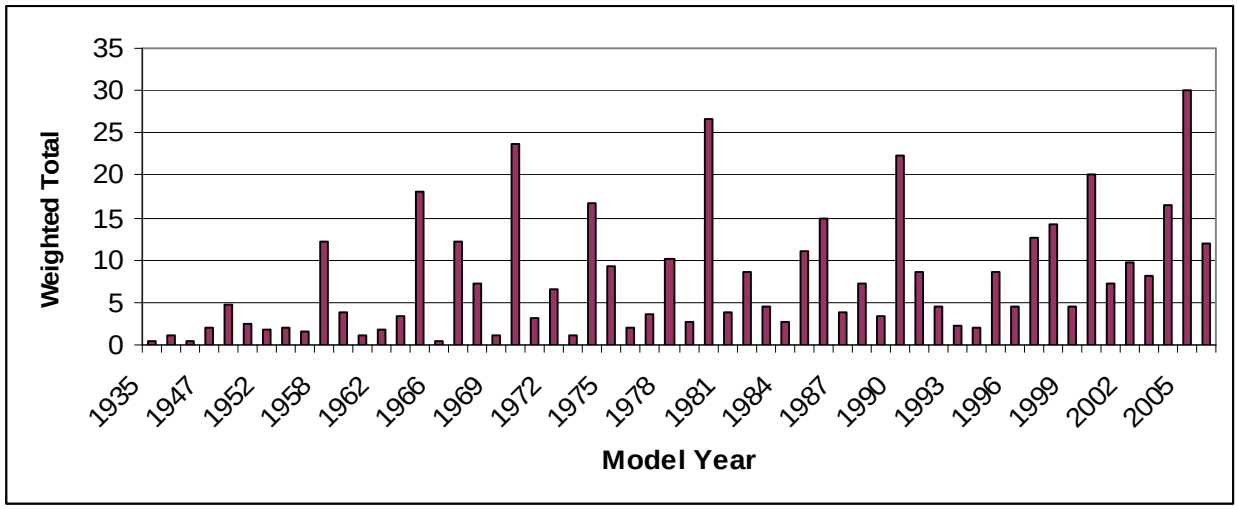
Equipment Category	Weighted Count*	Missing Obs. (Weighted)	pre-85	85 - 89	90 - 94	95 - 99	2000 - 04	05+
Ag. Tractors - Diesel	433	350	47%	9%	9%	10%	14%	10%
Ag. Tractors - Gas	42	8	84%	2%	0%	4%	10%	0%
ATVs - Gas	51	11	8%	5%	12%	17%	39%	19%
Balers - Diesel	14	1	11%	11%	5%	41%	21%	10%
Combines - Diesel	12	3	11%	10%	25%	18%	24%	12%
Sprayers - Gas	22	23	21%	56%	12%	4%	5%	2%

* Weighted counts only provided for equipment categories *with* model year

Figure 11 provides a detailed breakout of the weighted model year distribution for diesel agricultural tractors.

[13] The limited number of observations, coupled with one respondent having purchased five diesel balers in 1998, causes a spike in the baler distribution in the 1995 – 1999 bin that is likely not representative of the population as a whole.

Figure 11. Model Year Distribution – Diesel Agricultural Tractors



Given the high age of many of the agricultural tractors recorded in the survey, a separate analysis was conducted to determine if there was an inverse correlation between equipment age and activity for this equipment category, under the assumption that older equipment requires more maintenance and is slowly phased out in favor of newer equipment. However, Figure 12 indicates no clear relationship between age and utilization for diesel agricultural tractors.

Figure 12. Diesel Agricultural Tractor Hrs/Yr vs. Age

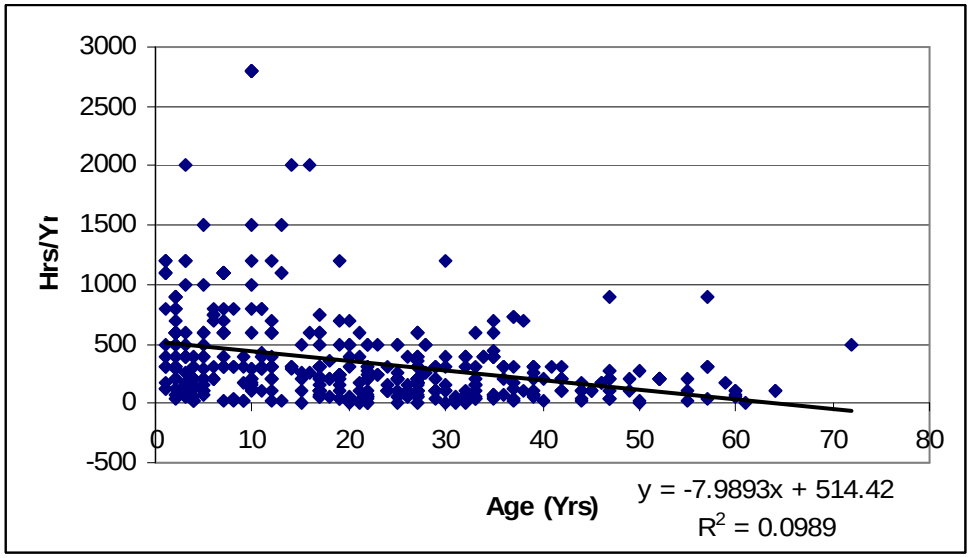


Table 54 presents the model year distribution for the most common equipment/fuel type combinations in the Construction and Mining sector. In general, the smaller equipment categories (air compressors, generator sets, and skid steer loaders) appear to have newer age distributions than heavier equipment (loaders and backhoes). Granularity is again a concern, with spikes appearing in the 2005 – 2006 period for diesel air compressors and gasoline generator sets, due to a small number of respondents making multiple equipment purchases in

the same year (with one respondent purchasing five diesel air compressors in 2005, and two respondents purchasing 13 gas generator sets in 2006.) Nevertheless, the overall trend toward newer equipment is evident compared to the agricultural equipment presented in Table 53.

Table 54. Model Year Distribution for Selected Equipment – Construction and Mining Sector

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	Pre-97	97 - 98	99 - 00	01 - 02	03 - 04	05 - 06
Air Compressors	Diesel	17	11	18%	18%	5%	0%	12%	47%
Air Compressors	Gasoline	31	23	7%	7%	25%	7%	24%	31%
Generator Sets	Gasoline	57	23	7%	5%	15%	10%	21%	43%
Rubber Tired Loaders	Diesel	17	0	33%	7%	15%	20%	0%	24%
Skid Steer Loaders	Diesel	19	10	10%	26%	7%	13%	23%	22%
Tractors/Loaders/Backhoes	Diesel	47	34	40%	2%	13%	10%	10%	25%

* Weighted counts only provided for equipment categories *with* model year

Table 55 presents the model year distribution for the most common equipment/fuel type combinations in the Residential sector. The equipment in this sector is highly weighted toward newer model years, relative to the other sectors, with approximately 50% of units being five years of age or less.

Table 55. Model Year Distribution for Selected Equipment – Residential Sector

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	Pre-97	97 - 98	99 - 00	01 - 02	03 - 04	05+
Chainsaws	Gasoline	48	23	12%	31%	6%	12%	12%	27%
Front/Riding Mowers	Gasoline	22	4	25%	0%	12%	19%	20%	24%
Lawn Mowers	Gasoline	194	51	16%	11%	12%	12%	18%	31%
Leaf Blowers/Vacuums	Gasoline	26	7	0%	10%	0%	11%	36%	43%
Off-Road Motorcycles	Gasoline	18	1	24%	0%	0%	16%	37%	24%
Trimmers/Edgers/Brush Cutters	Gasoline	67	23	16%	6%	10%	6%	23%	38%

* Weighted counts only provided for equipment categories *with* model year

Table 56 presents the model year distribution for the most common equipment/fuel type combinations in the Residual sector. Separate model year bins are used for gasoline equipment compared to diesel and compressed gas, to reflect the relatively shorter lifespan of gasoline engines. Overall, similar patterns hold as described above, with smaller gasoline units being newer than larger diesel units. The distribution for compressed gas industrial forklifts is roughly evenly distributed across the different model year bins. Again, the relatively high percentages in the 1999 – 2001 bin for chainsaws and trimmers/edgers/brushcutters is due to single respondents purchasing relatively large numbers of units in a single year (seven chainsaws and 14 trimmers in 2000).

Table 56. Model Year Distribution for Selected Equipment – Residual Sector

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	Pre-85	85 - 89	90 - 94	95 - 99	00 - 04	05+
Ag. Tractors	Diesel	42	2	56%	0%	0%	21%	16%	6%
Industrial forklifts	Comp. Gas	77	69	19%	3%	9%	18%	38%	13%
Rubber Tired Loaders	Diesel	11	1	40%	20%	9%	12%	18%	0%
Tractors/Loaders/Backhoes	Diesel	13	7	20%	0%	20%	20%	41%	0%

Equipment Type	Fuel Type	Weighted Count*	Missing Obs. (Weighted)	Pre-95	96 - 98	99 - 01	02 - 04	05+
Chainsaws	Gasoline	11	2	0%	10%	57%	13%	20%
Front/Riding Mowers	Gasoline	10	2	8%	17%	18%	38%	18%
Trimmers/Edgers/Brush Cutters	Gasoline	18	1	0%	6%	62%	16%	16%

* Weighted counts only provided for equipment categories *with* model year

3.2 Equipment Instrumentation Results

The engine operation data collected on in-use construction equipment was processed and evaluated to provide basic descriptive statistics regarding engine on time, operation mode (inferred idle vs. load), and exhaust gas temperature distributions for each piece of equipment instrumented in the study, as described below. Although the data collected cover a diverse group of equipment categories and applications, the study did not attempt to provide comprehensive coverage of the significant equipment use patterns in the construction industry. Since the engine selection process itself was not based on a statistically-based sampling plan, the subsequent data analysis does not aggregate the results across equipment categories or application types in order to estimate average hours per day or representative exhaust gas temperature profiles for the construction sector as a whole. Nevertheless, the disaggregated, equipment-specific data presented below provides an informative set of "snap-shots" of some of the more common construction equipment types and applications.

3.2.1 Instrumentation Data Processing

ERG processed engine data downloaded from the Cleaire data loggers to compile and assess activity and exhaust temperature from the equipment described in Table 4 (see Section 2.2.4). To do so, each raw engine file was input into a Statistical Analysis Software (SAS) dataset. The raw data consisted of header information, followed by rows of observations, each containing a date, time, RPM, and temperature (in deg C) for a 2-second interval. Occasionally, a record would contain a flag indicating the engine was starting or ending its recording of information.

The data provided was fairly uniform, although some files used an alternative date format. Using the information provided in Table 4, locations and equipment descriptions were appended to the raw data.

Note that a very small fraction of observations, (those with RPM readings < 400) were removed from the data for the analysis assuming actual idle operation does not occur below this level.

3.2.2 Operation Profiles

As each record represents two seconds of operating time, the number of observations for each piece of equipment on a given day can be used to calculate hourly activity. Table 57 presents the daily activity information calculated from the data. (The number of days the engine was actually operated over the seven day instrumentation period ranged from as few as one to as many as seven, as seen in Table 4). Hours per day values varied dramatically, even for the same piece of equipment on different days. Daily engine on time varied from just a few minutes to over 11 hours a day.

Histograms showing exhaust gas temperature distributions (in bins of 50 degrees C) were created for each individual data file, and are presented in Appendix F. These data show a wide variety of operation temperature patterns, with modal temperature bins (i.e., "peaks") ranging from as low as 100 degrees C to as high as 550 degrees C. Temperature ranges can be narrow, as is the case with several backhoes with min/max ranges less than 200 degrees. Other engines demonstrate a very broad operational range, commonly operating as low as 200 degrees but reaching temperatures above 550 degrees C. The temperature distributions themselves often have a single peak, although a limited number demonstrated bi-modal distributions, indicative of possible "low" and "high" modes of operation.

In order to estimate approximate percentages for engine idle/loaded operation modes, histograms of RPM data were evaluated to determine an approximate baseline idle RPM for each piece of equipment. Scatter plots of RPM versus time clearly showed a lower bound to the operating RPM of each engine, although the specific lower bounds could vary markedly across engines. SAS routines were then used to determine the percentage of observations falling within the designated RPM "band" (assumed to represent idle operation), and the remaining, higher RPM values (assumed to represent loaded operation).[14] The calculated fraction of time at load and idle for each file are presented in Table 58. Although substantial variation is evident, most of the equipment instrumented for this study appears to be operating under some sort of load for the majority of their engine-on time.

[14] RPM by itself cannot be used to definitely identify engine load. For example, high idle events can occur while engines are not under load. However, direct measurement of engine load was beyond the scope and resources of this effort.

Table 57. Instrumented Vehicle Daily Activity Profiles

Equipment ID	Observations (2-second intervals)	Hours/day	Unit Description
s20070401_1	7,951	4.42	Loader
s20070503_1	400	0.22	Loader
s20070503_1	1,329	0.74	Loader
s20070503_1	820	0.46	Loader
s20070503_1	615	0.34	Loader
s20070508_1	5,148	2.86	Backhoe
s20070508_1	3,437	1.91	Backhoe
s20070508_1	2,625	1.46	Backhoe
s20070508_1	4,076	2.26	Backhoe
s20070515_1	6,690	3.72	Backhoe
s20070515_1	2,378	1.32	Backhoe
s20070515_1	1,803	1	Backhoe
s20070515_1	517	0.29	Backhoe
s20070515_2	10,615	5.9	Grinder
s20070515_2	10,844	6.02	Grinder
s20070515_2	7,701	4.28	Grinder
s20070515_2	6,288	3.49	Grinder
s20070515_2	11,793	6.55	Grinder
s20070515_3	1,351	0.75	Loader
s20070515_3	610	0.34	Loader
s20070515_3	3,562	1.98	Loader
s20070516_1	316	0.18	Loader
s20070516_1	1,341	0.75	Loader
s20070516_1	909	0.51	Loader
s20070517_1	111	0.06	Backhoe
s20070517_1	242	0.13	Backhoe
s20070517_1	2,035	1.13	Backhoe

Equipment ID	Observations (2-second intervals)	Hours/day	Unit Description
s20070521_1	10,339	5.74	Compactor
s20070521_1	17,994	10	Compactor
s20070521_1	13,870	7.71	Compactor
s20070522_1	7,646	4.25	Screener
s20070522_1	4,984	2.77	Screener
s20070522_1	11,865	6.59	Screener
s20070522_1	6,134	3.41	Screener
s20070522_1	5,066	2.81	Screener
s20070522_2	1,004	0.56	Backhoe
s20070522_2	8,405	4.67	Backhoe
s20070522_2	8,812	4.9	Backhoe
s20070522_2	5,310	2.95	Backhoe
s20070523_1	271	0.15	Loader
s20070524_1	2,129	1.18	Backhoe
s20070524_1	4,496	2.5	Backhoe
s20070524_1	2,299	1.28	Backhoe
s20070526_1	166	0.09	Loader
s20070526_1	1,592	0.88	Loader
s20070529_1	6,231	3.46	Grinder
s20070529_1	11,498	6.39	Grinder
s20070529_1	8,009	4.45	Grinder
s20070529_1	6,596	3.66	Grinder
s20070529_1	5,263	2.92	Grinder
s20070529_2	17,065	9.48	Compactor
s20070529_2	18,245	10.14	Compactor
s20070529_2	20,290	11.27	Compactor
s20070529_2	18,161	10.09	Compactor

Equipment ID	Observations (2-second intervals)	Hours/day	Unit Description
s20070529_2	5,547	3.08	Compactor
s20070530_1	9,602	5.33	Grader
s20070530_1	9,385	5.21	Grader
s20070530_1	13,095	7.28	Grader
s20070530_1	5,273	2.93	Grader
s20070530_1	10,864	6.04	Grader
s20070530_1	11,650	6.47	Grader
s20070530_1	8,977	4.99	Grader
s20070530_2	6,337	3.52	Loader
s20070530_2	10,818	6.01	Loader
s20070530_2	10,668	5.93	Loader
s20070530_2	5,409	3.01	Loader
s20070530_2	7,145	3.97	Loader
s20070530_2	19	0.01	Loader
s20070531_1	4,623	2.57	Backhoe
s20070531_1	3,520	1.96	Backhoe
s20070531_1	5,649	3.14	Backhoe
s20070531_1	2,958	1.64	Backhoe
s20070601_1	537	0.3	Backhoe
s20070602_1	830	0.46	Backhoe
s20070602_1	10,590	5.88	Backhoe
s20070602_1	1,562	0.87	Backhoe
s20070602_2	3,522	1.96	Loader
s20070602_2	10,840	6.02	Loader
s20070602_2	14,116	7.84	Loader
s20070602_2	13,346	7.41	Loader
s20070602_2	10,659	5.92	Loader
s20070602_2	15,559	8.64	Loader
s20070604_1	18,458	10.25	Dozer

Equipment ID	Observations (2-second intervals)	Hours/day	Unit Description
s20070604_1	18,413	10.23	Dozer
s20070604_1	14,262	7.92	Dozer
s20070604_1	9,705	5.39	Dozer
s20070604_1	5,980	3.32	Dozer
s20070605_1	10,590	5.88	Screener
s20070605_1	1,562	0.87	Screener
s20070605_2	10,100	5.61	Compactor
s20070605_2	12,791	7.11	Compactor
s20070605_2	5,273	5.96	Compactor
s20070605_2	12,655	7.03	Compactor
s20070605_2	13,183	7.32	Compactor
s20070605_2	7,441	4.13	Compactor
s20070605_3	1,133	0.63	Backhoe
s20070605_3	1,136	0.63	Backhoe
s20070605_3	4,993	2.77	Backhoe
s20070605_3	3,785	2.1	Backhoe
s20070606_1	6,776	3.76	Loader
s20070606_1	12,901	7.17	Loader
s20070606_1	2,423	1.35	Loader
s20070606_1	7,111	3.95	Loader
s20070606_2	5,077	2.82	Rubber Wheel Loader
s20070606_2	10,659	5.92	Rubber Wheel Loader
s20070606_2	15,559	8.64	Rubber Wheel Loader
s20070606_2	12,001	6.67	Rubber Wheel Loader
s20070606_2	12,430	6.91	Rubber Wheel Loader
s20070607_1	3,037	1.69	Backhoe
s20070609_1	12,001	6.67	Loader
s20070609_1	12,430	6.91	Loader
s20070609_1	10,719	5.96	Loader

Equipment ID	Observations (2-second intervals)	Hours/day	Unit Description
s20070609_1	16,310	9.06	Loader
s20070609_1	14,004	7.78	Loader
s20070609_1	11,377	6.32	Loader
s20070609_1	13,622	7.57	Loader
s20070612_1	3,278	1.82	Backhoe
s20070614_1	11,377	6.32	Dozer
s20070614_1	13,622	7.57	Dozer
s20070614_1	10,433	5.8	Dozer
s20070614_1	10,015	5.56	Dozer
s20070614_1	7,779	4.32	Dozer
s20070614_1	739	0.41	Dozer
s20070614_1	6,754	3.75	Dozer
s20070615_1	10,983	6.1	Loader
s20070615_1	154	0.09	Loader
s20070615_1	1,150	0.64	Loader
s20070615_1	7,742	4.3	Loader
s20070615_1	10,701	5.95	Loader
s20070615_1	5,947	3.3	Loader
s20070615_1	6,770	3.76	Loader
s20070616_1	10,433	5.8	Loader
s20070616_1	10,015	5.56	Loader
s20070616_1	7,779	4.32	Loader
s20070616_1	739	0.41	Loader
s20070616_1	6,593	3.66	Loader
s20070622_1	9,697	5.39	Loader
s20070622_1	10,366	5.76	Loader
s20070622_1	7,214	4.01	Loader
s20070622_1	14,236	7.91	Loader
s20070622_1	2,447	1.36	Loader

Equipment ID	Observations (2-second intervals)	Hours/day	Unit Description
s20070624_1	12,312	6.84	Loader
s20070624_1	11,808	6.56	Loader
s20070628_1	139	0.08	Backhoe
s20070628_1	8,349	4.64	Backhoe
s20070628_1	6,969	3.87	Backhoe
s20070628_1	8,162	4.53	Backhoe
s20070705_1	5,608	3.12	Backhoe
s20070705_1	2,648	1.47	Backhoe
s20070705_1	776	0.43	Backhoe
s20070705_1	7,818	4.34	Backhoe
s20070705_1	10,182	5.66	Backhoe
s20070705_1	5,715	3.18	Backhoe
s20070705_1	5,413	3.01	Backhoe
s20070709_1	10,719	5.96	Rubber Wheel Loader
s20070709_1	16,310	9.06	Rubber Wheel Loader
s20070709_1	14,004	7.78	Rubber Wheel Loader
s20070716_1	1,150	0.64	Loader
s20070716_1	10,701	5.95	Loader
s20070716_1	5,947	3.3	Loader
s20070718_1	682	0.38	Loader
s20070718_1	14,153	7.86	Loader
s20070718_1	14,674	8.15	Loader
s20070718_1	13,031	7.24	Loader
s20070718_1	15,584	8.66	Loader
s20070718_1	7,189	3.99	Loader
s20070718_1	12,147	6.75	Loader
s20070729_1	5,909	3.28	Backhoe
s20070729_1	8,850	4.92	Backhoe
s20070729_1	2,440	1.36	Backhoe

Equipment ID	Observations (2-second intervals)	Hours/day	Unit Description
s20070729_1	1,464	0.81	Backhoe
s20070729_1	246	0.14	Backhoe
s20070803_1	6,900	3.83	Wheel Loader
s20070803_1	13,254	7.36	Wheel Loader
s20070803_1	5,750	3.19	Wheel Loader
s20070803_1	9,270	5.15	Wheel Loader
s20070803_1	82	0.05	Wheel Loader
s20070823_1	153	0.09	Backhoe
s20070823_1	1,217	0.68	Backhoe
s20070823_1	1,636	0.91	Backhoe
s20070823_1	3,635	2.02	Backhoe
s20070824_1	642	0.36	Wheel Loader
s20070824_1	5,386	2.99	Wheel Loader
s20070824_1	2,637	1.47	Wheel Loader
s20070824_2	1,495	0.83	Scraper
s20070824_2	3,465	1.93	Scraper
s20070824_2	5,867	3.26	Scraper
s20070824_2	5,140	2.86	Scraper
s20070824_2	4,814	2.67	Scraper
s20070824_2	6,865	3.81	Scraper
s20070824_3	1,772	0.98	Dozer
s20070824_3	7,927	4.4	Dozer
s20070824_3	400	0.22	Dozer
s20070824_3	4,964	2.76	Dozer
s20070826_1	12,677	7.04	Compactor
s20070826_1	5,212	2.9	Compactor
s20070830_1	266	0.15	Backhoe
s20070830_1	669	0.37	Backhoe
s20070830_1	4,147	2.3	Backhoe

Equipment ID	Observations (2-second intervals)	Hours/day	Unit Description
s20070831_1	8,183	4.55	4WD Tractor Root Plow
s20070831_1	6,622	3.68	4WD Tractor Root Plow
s20070831_1	8,210	4.56	4WD Tractor Root Plow
s20070831_1	8,207	4.56	4WD Tractor Root Plow
s20070831_1	4,441	2.47	4WD Tractor Root Plow
s20070831_2	1,457	0.81	Wheel Loader
s20070831_2	5,256	2.92	Wheel Loader
s20070831_3	5,229	2.91	Scraper
s20070831_3	4,762	2.65	Scraper
s20070831_3	8,390	4.66	Scraper
s20070831_3	6,739	3.74	Scraper
s20070831_3	5,815	3.23	Scraper
s20070831_4	6,958	3.87	Dozer
s20070831_4	99	0.06	Dozer
s20070831_4	4,304	2.39	Dozer
s20070831_4	4,784	2.66	Dozer
s20070906_1	5,544	3.08	Excavator
s20070906_1	15,464	8.59	Excavator
s20070906_1	14,333	7.96	Excavator
s20070906_1	13,926	7.74	Excavator
s20070906_1	14,269	7.93	Excavator
s20070906_1	14,173	7.87	Excavator
s20070906_1	14,474	8.04	Excavator
s20070907_1	7,285	4.05	Claw Tractor/Loader
s20070907_1	11,117	6.18	Claw Tractor/Loader
s20070907_1	8,343	4.64	Claw Tractor/Loader
s20070907_1	9,949	5.53	Claw Tractor/Loader
s20070907_1	9,442	5.25	Claw Tractor/Loader
s20070913_1	13,857	7.7	Excavator

Equipment ID	Observations (2-second intervals)	Hours/day	Unit Description
s20070913_1	14,262	7.92	Excavator
s20070913_1	14,202	7.89	Excavator
s20070917_1	11,091	6.16	Claw Tractor/Loader
s20070917_1	742	0.41	Claw Tractor/Loader
s20070917_1	75	0.04	Claw Tractor/Loader
s20070917_1	163	0.09	Claw Tractor/Loader
s20070919_1	14,225	7.9	Excavator
s20070919_1	12,922	7.18	Excavator
s20070919_1	14,441	8.02	Excavator
s20070919_1	11,799	6.56	Excavator
s20070923_1	12,196	6.78	Compactor
s20070923_1	9,665	5.37	Compactor
s20070926_1	182	0.1	Claw Tractor/Loader
s20070926_1	102	0.06	Claw Tractor/Loader
s20070926_1	35	0.02	Claw Tractor/Loader
s20070930_1	6,786	3.77	Wheel Loader
s20070930_1	8,724	4.85	Wheel Loader
s20070930_1	4,638	2.58	Wheel Loader
s20071004_1	12,036	6.69	Claw Tractor/Loader
s20071004_1	11,523	6.4	Claw Tractor/Loader
s20071004_1	11,631	6.46	Claw Tractor/Loader
s20071004_1	12,008	6.67	Claw Tractor/Loader
s20071004_1	5,681	3.16	Claw Tractor/Loader
s20071010_1	8,173	4.54	Rubber Wheel Loader
s20071010_1	10,237	5.69	Rubber Wheel Loader
s20071010_1	12,039	6.69	Rubber Wheel Loader
s20071018_1	12,663	7.04	Rubber Wheel Loader
s20071018_1	9,469	5.26	Rubber Wheel Loader
s20071018_1	7,713	4.29	Rubber Wheel Loader
s20071018_1	1,544	0.86	Rubber Wheel Loader
s20071018_1	16,026	8.9	Rubber Wheel Loader
s20071018_1	12,362	6.87	Rubber Wheel Loader
s20071025_1	441	0.25	Compactor
s20071025_1	12,525	6.96	Compactor
s20071101_1	468	0.26	Compactor
s20071101_1	1,972	1.1	Compactor
s20071101_1	8,724	4.85	Compactor
s20071108_1	711	0.4	Compactor
s20071108_1	2,226	1.24	Compactor
s20071108_1	3,513	1.95	Compactor
s20071112_1	9,529	5.29	Rubber Wheel Loader
s20071112_1	75	0.04	Rubber Wheel Loader
s20071112_1	17,156	9.53	Rubber Wheel Loader
s20071112_1	14,616	8.12	Rubber Wheel Loader
s20071115_1	3,403	1.89	Compactor
s20071115_1	9,817	5.45	Compactor
s20071115_1	945	0.53	Compactor
s20071115_1	2,742	1.52	Compactor
s20071115_1	10,696	5.94	Compactor
s20071124_1	562	0.31	Compactor
s20071124_1	446	0.25	Compactor

Table 58. Fraction of Time at Load and Idle based on RPM

Filename	Unit Type	Load (Percent)	Idle (Percent)
s20070503_1	Loader	51.9	48.1
s20070508_1	Backhoe	70.8	29.2
s20070515_1	Backhoe	22.2	77.8
s20070515_2	Grinder	88.9	11.1
s20070515_3	Loader	58.2	41.8
s20070516_1	Loader	42.5	57.5
s20070517_1	Backhoe	88.3	11.7
s20070521_1	Compactor	92.7	7.3
s20070522_1	Screener	85.2	14.8
s20070522_2	Backhoe	88.5	11.5
s20070523_1	Loader	83.0	17.0
s20070524_1	Backhoe	94.6	5.4
s20070526_1	Loader	93.7	6.3
s20070529_1	Grinder	86.1	13.9
s20070529_2	Compactor	89.2	10.8
s20070530_1	Grader	90.4	9.6
s20070530_2	Loader	72.3	27.7
s20070531_1	Backhoe	88.2	11.8
s20070601_1	Backhoe	82.9	17.1
s20070602_1	Backhoe	86.0	14.0
s20070602_2	Loader	60.6	39.4
s20070604_1	Dozer	93.2	6.8
s20070605_1	Screener	85.5	14.5
s20070605_2	Compactor	77.4	22.6
s20070605_3	Backhoe	87.2	12.8
s20070606_1	Loader	64.7	35.3
s20070606_2	Rubber Wheel Loader	52.2	47.8
s20070607_1	Backhoe	88.1	11.9
s20070609_1	Loader	54.3	45.7
s20070612_1	Backhoe	89.8	10.2
s20070614_1	Dozer	51.5	48.5
s20070615_1	Loader	77.0	23.0
s20070616_1	Loader	46.2	53.8
s20070622_1	Loader	55.3	44.7
s20070624_1	Loader	91.9	8.1
s20070628_1	Backhoe	88.2	11.8
s20070705_1	Backhoe	75.2	24.8
s20070709_1	Rubber Wheel Loader	55.7	44.3
s20070716_1	Loader	78.5	21.5
s20070718_1	Loader	84.8	15.2
s20070729_1	Backhoe	93.4	6.6
s20070803_1	Wheel Loader	54.5	45.5
s20070823_1	Backhoe	85.3	14.7
s20070824_1	Wheel Loader	72.6	27.4

Filename	Unit Type	Load (Percent)	Idle (Percent)
s20070824_2	Scraper	82.7	17.3
s20070824_3	Dozer	96.6	3.4
s20070826_1	Compactor	79.8	20.2
s20070830_1	Backhoe	81.7	18.3
s20070831_1	4WD Tractor Root Plow	96.2	3.8
s20070831_2	Wheel Loader	82.3	17.7
s20070831_3	Scraper	86.2	13.8
s20070831_4	Dozer	93.5	6.5
s20070906_1	Excavator	83.9	16.1
s20070907_1	Claw Tractor/Loader	57.6	42.4
s20070913_1	Excavator	72.3	27.7
s20070917_1	Claw Tractor/Loader	51.5	48.5
s20070919_1	Excavator	75.5	24.5
s20070923_1	Compactor	68.8	31.2
s20070926_1	Claw Tractor/Loader	15.7	84.3
s20070930_1	Wheel Loader	57.3	42.7
s20071004_1	Claw Tractor/Loader	58.9	41.1
s20071010_1	Rubber Wheel Loader	62.2	37.8
s20071018_1	Rubber Wheel Loader	68.6	31.4
s20071025_1	Compactor	91.2	8.8
s20071101_1	Compactor	69.2	30.8
s20071108_1	Compactor	79.5	20.5
s20071112_1	Rubber Wheel Loader	66.6	33.4
s20071115_1	Compactor	53.5	46.5
s20071124_1	Compactor	45.8	54.2

4.0 Analysis and Discussion

The equipment characterization survey results and instrumentation findings were analyzed to determine equipment population and operation characteristics. Survey data were first extrapolated to generate state level equipment population estimates and operation profiles using appropriate surrogates. Statistical and quality assurance analyses were then performed to assess the overall representativeness and uncertainty associated with the state level projections. In addition, a detailed analysis was performed on the projected state level profiles to assess equipment preemption status with respect to federal requirements for construction and agricultural equipment less than 175 hp. Finally, a more qualitative analysis was conducted using the equipment instrumentation data to broadly characterize engine operating times and exhaust gas temperature distributions.

4.1 Statewide Equipment Profile Development

The survey data provided the basis for estimating statewide equipment populations, average hours of activity, and hp distributions for targeted off-road equipment/fuel type combinations less than 175 hp. Expansion of the survey data involved several steps, as described below.

4.1.1 Identification and Selection of Surrogates

In order to make inferences regarding the off-road equipment population as a whole in California based on sample data taken from that population, the sample results must be expanded upward using a reliable surrogate. Surrogates may then be used to allocate the statewide totals down to smaller geographic regions such as counties. The surrogates selected must be readily tied to the available survey data fields. For example, based on the survey results we know the percentage of occupied households that reported owning a lawn mower. Therefore the total number of residential lawn mowers in the state could be estimated by multiplying the ownership percentage derived from the survey data by the total number of occupied households in California. In this case the chosen surrogate is the number of occupied households in California. While personal income might prove to be more closely correlated with lawn mower ownership and hence a better expansion surrogate, it could not be applied to the data since the personal income of individual survey respondents was not available from the survey data.

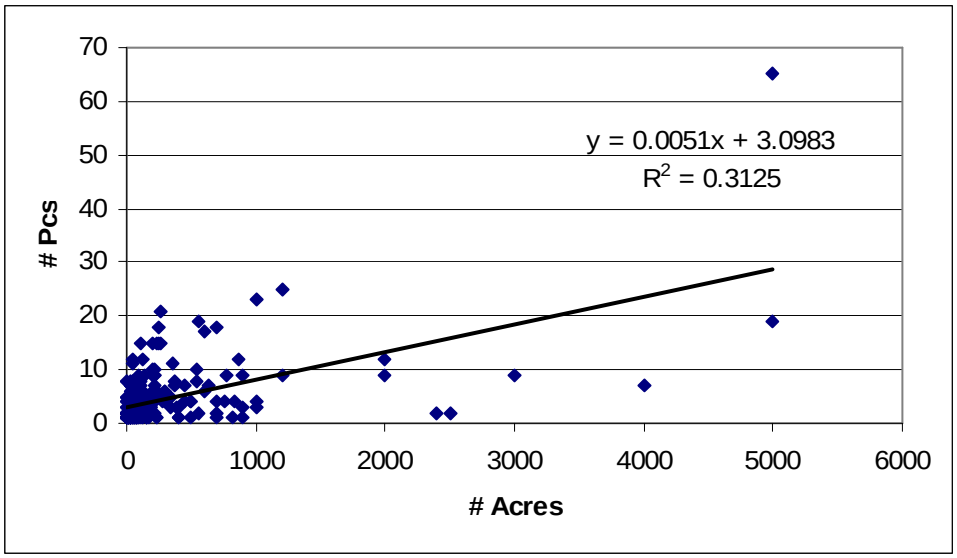
The potential surrogates for this study varied across the different sectors. Possible surrogates for the Agricultural sector included the number of farms, total acreage, and total head of cattle (for the CAFO/diary strata). Potential surrogates for the Construction and Mining, and Residual sectors included number of employees and the number of establishments. The preferred surrogate for the Residential sector was the number of occupied households, since other demographic data was not available for the respondents.

Agricultural Sector Surrogates

Survey data from within the Agricultural sector were investigated to determine if a positive relationship existed between non-electric equipment counts and acreage among respondents. To the extent that larger establishments tend to have more equipment, acreage will be preferred as a surrogate over the total number of establishments. Figure 13 shows the relationship between

reported acreage and total pieces of equipment within the sector for non-CAFO/Dairy respondents. Although the relationship between the two parameters is not strong (with an r-square value of 0.31, it demonstrates a positive correlation. For this reason reported acreage was selected as the preferred surrogate for this sector.

Figure 13. Number of Equipment Pieces vs. Reported Acreage, Non-CAFO/Dairy Agricultural Sector Respondents



Harvested acreage was compiled for each survey strata in the Agricultural sector from the 2002 California Agricultural Census.(8) Table 59 presents the acreage totals for the surveyed respondents as well as state totals. Survey totals include both eligible and ineligible respondents.[15] Note that number of head are provided as the surrogate for the CAFO/Dairy strata, also obtained from the 2002 Census.[16] The table also indicates survey coverage for each stratum as a percent of the total state.

Table 59. Surrogate Totals – Survey and Statewide Values for Agricultural Sector

Surrogate Counts	Citrus (acres)	CAFO/Dairy (# head)	Nut (acres)	Row (acres)	Tree Fruit (acres)	Vineyard/Other (acres)
Survey	3,113	24,526	26,880	38,570	10,053	44,185
State	927,899	4,552,237	1,108,984	8,255,732	658,967	994,682
Percent Coverage	**0.34%**	**0.54%**	**2.42%**	**0.47%**	**1.53%**	**4.44%**

[15] Ineligible respondents consisted of establishments that were within the Agricultural sample frame but did not operate any targeted off-road equipment.

[16] Number of head of cattle did not show any clear relationship to the reported number of equipment pieces within the CAFO/Dairy stratum. Although this surrogate may not provide any improvement over the simple number of CAFO/Dairy establishments, number of head (as determined from the 2002 Agricultural Census) was selected as the surrogate to be consistent with the approach adopted for the remainder of the Agricultural sector.

Note that no data were available regarding total acres harvested during 2007 as of this writing, so adjustments could not be made to the surrogates for the base inventory year for this sector.

Construction/Mining and Residual Surrogates

SSI provided an estimate of the number of people employed by each of the respondents in the Construction and Mining, and Residual sectors. The SSI sample records provided employee bin sizes rather than point estimates. ERG assumed midpoint values for each SSI employee size bin, as shown in Table 60. For this analysis a point value of 1,500 employees was assumed for the largest SSI size bin.

Table 60. SSI Employee Size Bins and Assumed Point Estimates – Construction/Mining and Residual Sectors

# Employees	Point Estimate
1 - 4	2.5
5 - 9	7
10 - 19	14.5
20 - 49	34.5
50 - 99	74.5
100 - 249	174.5
250 - 499	374.5
500 - 999	749.5
1,000+	1,500

The relationship between the estimated number of employees and the number of pieces of equipment owned/operated by each respondent was evaluated, as shown in Figures 14 and 15 for the Construction/Mining and Residual sectors, respectively. In both cases the relationship between number of employees and equipment totals is very weak. For this reason the simple number of establishments was selected as the surrogate for these sectors. However, employee count data from the California Regional Economies Employment (CREE) series was ultimately used to allocate state equipment populations to the county level, however, as described below.(9)

Figure 14. Number of Equipment Pieces vs. Reported Acreage, Construction/Mining Sector Respondents

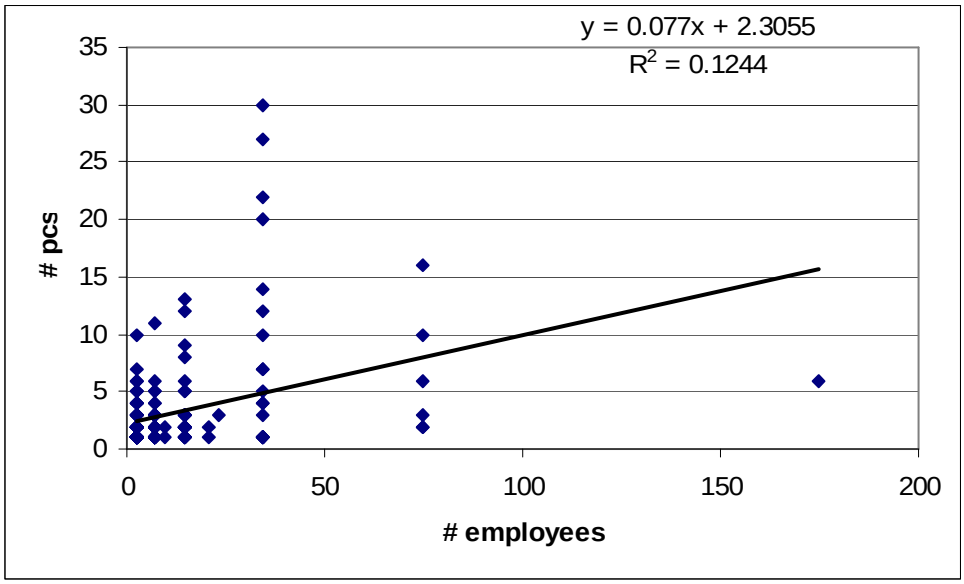
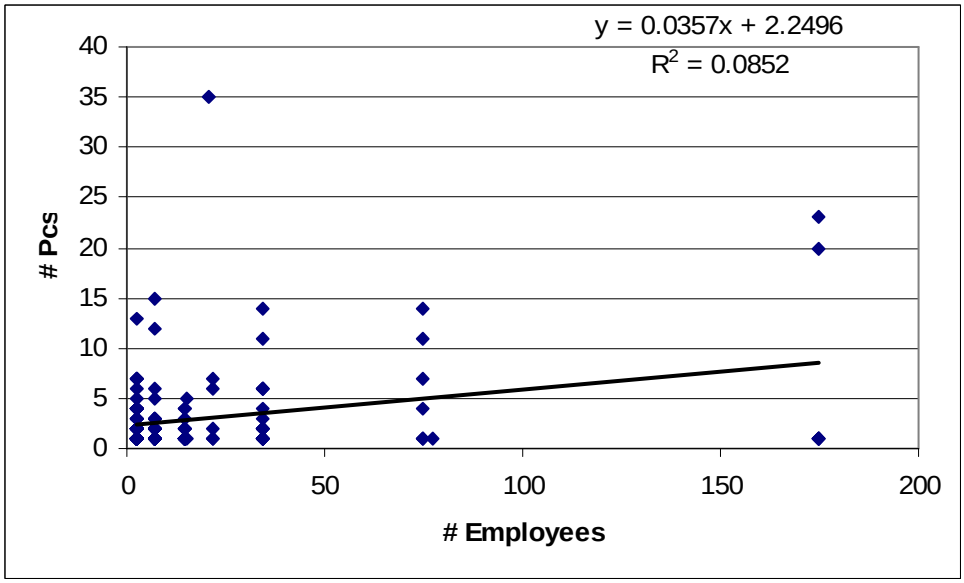


Figure 15. Number of Equipment Pieces vs. Reported Acreage, Residual Sector Respondents



USA Data maintains a comprehensive listing of business establishments operating across the country for survey sampling purposes.(10) The USA Data database was queried to obtain the number of establishments at the state level in different SIC groups corresponding to the Construction and Mining, and Residual sectors. Table 61 provides the query results, along with the total number of survey respondents, for the Construction and Mining sector. Again, respondent totals include both eligible and ineligible establishments.

Table 61. Surrogate Totals – Survey and Statewide Values for Construction/Mining Sector

# Establishments	Construction-a	Construction-b	Construction-c	Mining
SIC Range	1500s	1600s	1700s	1000s - 1400s
Survey	311	46	684	61
State	39,777	4,920	69,752	487
Percent Coverage	**0.8%**	**0.9%**	**1.0%**	**12.5%**

Table 62 provides the SICs included in the query for the Residual sector, and Table 63 provides the corresponding query results and respondent totals.

Table 62. Residual Sector SIC Groupings by Survey Strata

Residual Strata	SIC(s)
Logging	2411
Res-a	0723, 0724, 0741, 0751, 0752, 0761, 0781, 0782, 0783, 0800s, 0900s
Res-b	2000s - 4000s
Res-c	5000 - 5199
Res-d	5200 - 5599, 5700s
Res-e	7000 - 7099, 7500 - 7599, 7800 - 7999, 8200 - 8299, 8400 - 8499
Res-f	9100 - 9299, 9700 - 9799

Table 63. Surrogate Totals – Survey and Statewide Values for Residual Sector

# Establishments	Logging	Res-a	Res-b	Res-c	Res-d	Res-e	Res-f
Survey	13	90	382	289	289	345	10
State	307	21,802	153,260	115,654	120,789	137,000	9,433
Percent Coverage	**4.23%**	**0.41%**	**0.25%**	**0.25%**	**0.24%**	**0.25%**	**0.11%**

Residential Surrogates

US Census data on households were obtained at the state and county level for 2006, the most recent year available.(11) Household counts were adjusted downward by 7.8% to adjust for unoccupied households.(12) Occupied household totals were then increased by 0.26%, the estimated statewide population increase from 2006 to 2007, to obtain a final estimate of occupied households in the 2007 survey year.(13) Occupied household totals for the survey and state are provided in Table 64 for the target and other area strata for the Residential sector.

Table 64. Surrogate Totals – Survey and Statewide Values for Residential Sector

# Occupied Households	Target	Other Areas
Survey	265	1,302
State	378,301	10,850,415
Percent Coverage	**0.070%**	**0.012%**

4.1.2 Statewide Equipment Population Estimates

Once surrogates were identified and obtained for each survey stratum and sector, they were applied to the weighted survey equipment counts to estimate statewide population totals. The following steps were executed in this process:

1. For each sector and stratum, the total number of equipment pieces were summed for each equipment/fuel type combination;
2. Equipment/fuel type totals were then divided by the appropriate survey surrogate totals to obtain a frequency measure. For example, there was an average of 4.0 diesel agricultural tractors reported per 1,000 acres within the row crop stratum;
3. The resulting frequency proportions were multiplied by the corresponding statewide surrogate value to estimate state level equipment population totals.

Equipment Incidence Rates

Tables 65 through 68 present the equipment frequency proportions by survey strata for each sector.

Table 65. Equipment Type Incidence per 1,000 Acres – Agricultural Sector

Equipment Type	Fuel Type	Citrus	CAFO/ Dairy*	Nut	Row	Tree Fruit	Vineyard/ Other
Aerial Lifts	Gasoline	0.00	0.00	0.00	0.00	0.10	0.00
Ag Sweepers	Diesel	0.00	0.00	0.67	0.00	0.10	0.00
Ag Sweepers	Gasoline	0.00	0.00	0.07	0.00	0.00	0.00
Agricultural Mowers	Diesel	0.00	0.04	0.04	0.00	0.20	0.02
Agricultural Mowers	Gasoline	0.64	0.00	0.00	0.03	0.10	0.02
Agricultural Tractors	Comp. Gas	0.00	0.00	0.04	0.03	0.00	0.05
Agricultural Tractors	Diesel	16.38	2.57	6.03	3.99	10.84	6.63
Agricultural Tractors	Gasoline	2.57	0.29	0.22	0.57	0.70	0.27
All Terrain Vehicles	Diesel	0.32	0.00	0.26	0.03	0.00	0.02
All Terrain Vehicles	Gasoline	4.18	0.12	0.41	0.36	1.99	0.48
Balancers	Diesel	0.00	0.00	0.15	0.00	0.00	0.00
Bale Haulers	Diesel	0.00	0.00	0.00	0.00	0.00	0.02
Balers	Diesel	0.00	0.08	0.22	0.18	0.00	0.14
Balers	Gasoline	0.00	0.00	0.00	0.00	0.00	0.02
Chainsaws	Gasoline	0.64	0.00	0.00	0.00	0.00	0.00
Combines	Comp. Gas	0.00	0.00	0.07	0.00	0.00	0.00
Combines	Diesel	0.00	0.00	0.22	0.10	1.09	0.00
Combines	Gasoline	0.00	0.00	0.11	0.00	0.10	0.00
Cranes	Diesel	0.00	0.00	0.00	0.00	0.00	0.07
Cranes	Gasoline	0.00	0.00	0.00	0.00	0.00	0.02
Crawler Tractors	Gasoline	0.00	0.04	0.00	0.00	0.00	0.00
Excavators	Diesel	0.00	0.00	0.00	0.00	0.00	0.02
Excavators	Gasoline	0.00	0.00	0.04	0.00	0.00	0.00
Industrial forklifts	Comp. Gas	0.64	0.00	0.07	0.03	0.20	0.32

Equipment Type	Fuel Type	Citrus	CAFO/ Dairy*	Nut	Row	Tree Fruit	Vineyard/ Other
Industrial forklifts	Diesel	0.64	0.00	0.04	0.00	0.40	0.05
Industrial forklifts	Gasoline	0.00	0.00	0.11	0.03	0.10	0.02
Front/Riding Mowers	Gasoline	0.00	0.00	0.00	0.00	0.00	0.02
Generator Sets	Diesel	0.00	0.00	0.00	0.00	0.00	0.05
Generator Sets	Gasoline	0.00	0.04	0.00	0.00	0.00	0.02
Irrigation Sets	Diesel	0.00	0.00	0.00	0.05	0.00	0.00
Lawn Mowers	Gasoline	0.32	0.00	0.00	0.05	0.10	0.05
Leaf Blowers/Vacuums	Gasoline	0.32	0.00	0.00	0.00	0.00	0.00
Pruning Towers	Diesel	0.00	0.00	0.00	0.03	0.00	0.00
Pruning Towers	Gasoline	0.00	0.00	0.00	0.03	0.00	0.00
Pumps	Diesel	0.32	0.04	0.11	0.00	0.00	0.00
Pumps	Gasoline	0.00	0.00	0.00	0.00	0.00	0.02
Rubber Tired Loaders	Diesel	0.32	0.08	0.07	0.00	0.00	0.07
Rubber Tired Loaders	Gasoline	0.00	0.00	0.11	0.00	0.00	0.00
Shakers	Diesel	0.00	0.00	0.41	0.00	0.00	0.00
Shredders	Gasoline	0.00	0.00	0.00	0.00	0.00	0.02
Skid Steer Loaders	Diesel	0.00	0.04	0.00	0.00	0.00	0.00
Sprayers	Diesel	1.28	0.00	0.30	0.00	0.00	0.20
Sprayers	Gasoline	1.61	0.00	0.22	0.18	1.09	0.05
Spreaders	Comp. Gas	0.00	0.00	0.00	0.00	0.00	0.09
Swathers	Diesel	0.00	0.08	0.04	0.08	0.00	0.07
Swathers	Gasoline	0.00	0.00	0.04	0.00	0.00	0.00
Tillers	Gasoline	0.32	0.00	0.00	0.08	0.00	0.00
Tractors/Loaders/Backhoes	Diesel	0.64	0.04	0.07	0.05	0.10	0.05
Trenchers	Diesel	0.00	0.00	0.00	0.00	0.00	0.02
Trenchers	Gasoline	0.32	0.00	0.00	0.00	0.00	0.00
Trimmers/Edgers/Brush Cutters	Gasoline	0.32	0.00	0.00	0.00	0.30	0.05
Welders	Comp. Gas	0.00	0.00	0.00	0.03	0.00	0.00
Welders	Gasoline	0.32	0.00	0.00	0.00	0.00	0.00
Wood Splitters	Gasoline	0.32	0.00	0.00	0.00	0.10	0.00

* per 1,000 head

Table 66. Equipment Type Incidence per 1,000 Establishments – Construction/Mining Sector

Equipment Type	Fuel Type	Const-a	Const-b	Const-c	Mining
Aerial Lifts	Comp. Gas	3.2	0.0	0.0	0.0
Aerial Lifts	Diesel	3.2	0.0	1.5	0.0
Air Compressors	Comp. Gas	0.0	0.0	2.9	0.0
Air Compressors	Diesel	22.5	65.2	23.4	0.0
Air Compressors	Gasoline	9.6	173.9	64.3	82.0
Bore/Drill Rigs	Diesel	0.0	0.0	14.6	0.0
Bore/Drill Rigs	Gasoline	0.0	0.0	4.4	0.0
Cement and Mortar Mixers	Diesel	3.2	0.0	0.0	0.0
Cement and Mortar Mixers	Gasoline	0.0	0.0	4.4	0.0
Chippers/Stump Grinders	Diesel	0.0	0.0	0.0	16.4

Equipment Type	Fuel Type	Const-a	Const-b	Const-c	Mining
Concrete/Industrial Saws	Gasoline	0.0	0.0	3.8	0.0
Cranes	Diesel	0.0	0.0	4.4	0.0
Crawler Tractors	Diesel	0.0	65.2	4.4	0.0
Crawler Tractors	Gasoline	0.0	0.0	0.0	16.4
Excavators	Diesel	0.0	239.1	7.3	32.8
Industrial forklifts	Comp. Gas	0.0	65.2	11.7	344.3
Industrial forklifts	Diesel	0.0	0.0	11.7	0.0
Industrial forklifts	Gasoline	3.2	0.0	1.5	0.0
Front/Riding Mowers	Gasoline	9.6	0.0	0.0	0.0
Generator Sets	Comp. Gas	0.0	0.0	1.5	0.0
Generator Sets	Diesel	0.0	0.0	7.3	0.0
Generator Sets	Gasoline	45.0	108.7	83.3	65.6
Graders	Diesel	0.0	130.4	2.9	16.4
Hydro Power Units	Gasoline	0.0	0.0	1.5	0.0
Leaf Blowers/Vacuums	Gasoline	3.2	0.0	0.0	0.0
Materials Handling (Other)	Diesel	0.0	0.0	0.0	16.4
Pavers	Diesel	0.0	21.7	0.0	0.0
Paving Equipment	Gasoline	3.2	0.0	0.0	0.0
Pipe Threaders	Gasoline	0.0	0.0	2.9	0.0
Plate Compactors	Diesel	0.0	21.7	0.0	0.0
Pressure Washers	Gasoline	6.4	0.0	21.9	0.0
Pumps	Diesel	3.2	0.0	1.5	0.0
Pumps	Gasoline	0.0	0.0	8.8	0.0
Rollers	Diesel	0.0	130.4	14.6	0.0
Rollers	Gasoline	0.0	21.7	4.4	0.0
Rubber Tired Loaders	Diesel	6.4	239.1	10.2	131.1
Scrapers	Diesel	0.0	43.5	0.0	16.4
Signal Boards	Diesel	0.0	0.0	1.5	0.0
Skid Steer Loaders	Diesel	9.6	108.7	29.2	16.4
Snowmobiles	Gasoline	0.0	0.0	4.4	0.0
Sprayers	Diesel	0.0	0.0	1.5	0.0
Sprayers	Dual Gas/Electric	0.0	0.0	4.4	0.0
Sprayers	Gasoline	3.2	0.0	7.3	0.0
Storm Grinders	Diesel	0.0	0.0	0.0	16.4
Storm Grinders	Gasoline	0.0	0.0	0.0	16.4
Tillers	Gasoline	0.0	0.0	1.5	0.0
Tractors/Loaders/Backhoes	Comp. Gas	0.0	43.5	0.0	0.0
Tractors/Loaders/Backhoes	Diesel	19.3	347.8	92.1	114.8
Tractors/Loaders/Backhoes	Gasoline	0.0	0.0	1.5	0.0
Trenchers	Gasoline	0.0	0.0	1.5	0.0
Trimmers/Edgers/Brush Cutters	Gasoline	0.0	43.5	2.9	0.0
Vacuum	Gasoline	0.0	0.0	7.3	0.0
Vessels w/Outboard Engines	Gasoline	0.0	21.7	0.0	0.0
Welders	Diesel	0.0	0.0	1.5	16.4
Welders	Gasoline	0.0	0.0	4.4	16.4

Table 67. Equipment Type Incidence per 1,000 Occupied Households – Residential Sector

Equipment Type	Fuel Type	Target	Other Areas
Agricultural Tractors	Diesel	7.55	0.77
Agricultural Tractors	Gasoline	11.32	7.68
All Terrain Vehicles	Diesel	0.00	0.77
All Terrain Vehicles	Gasoline	22.64	4.61
Cement and Mortar Mixers	Gasoline	3.77	0.00
Chainsaws	Gasoline	128.30	35.33
Chippers/Stump Grinders	Gasoline	3.77	2.30
Front/Riding Mowers	Gasoline	45.28	13.06
Generator Sets	Gasoline	15.09	2.30
Golf Carts	Gasoline	3.77	1.54
Graders	Diesel	3.77	0.00
Lawn Mowers	Gasoline	230.19	125.96
Leaf Blowers/Vacuums	Gasoline	41.51	16.13
Minibikes	Gasoline	0.00	0.77
Off-Road Motorcycles	Gasoline	18.87	9.98
Personal Water Craft	Gasoline	0.00	2.30
Pressure Washers	Gasoline	7.55	2.30
Shredders	Gasoline	11.32	1.54
Snowblowers	Gasoline	18.87	0.00
Snowmobiles	Gasoline	3.77	0.00
Specialty Vehicles Carts	Gasoline	0.00	1.54
Sprayers	Gasoline	3.77	0.00
Tillers	Gasoline	7.55	7.68
Trimmers/Edgers/Brush Cutters	Comp. Gas	3.77	0.77
Trimmers/Edgers/Brush Cutters	Gasoline	109.43	46.08
Vessels w/Outboard Engines	Diesel	0.00	0.77
Vessels w/Outboard Engines	Gasoline	18.87	1.54

Table 68. Equipment Type Incidence per 1,000 Establishments – Residual Sector

Equipment Type	Fuel Type	Logging	Res-a	Res-b	Res-c	Res-d	Res-e	Res-f
Ag Sweepers	Diesel	0.00	11.11	0.00	0.00	0.00	0.00	0.00
Agricultural Mowers	Diesel	0.00	0.00	0.00	0.00	0.00	2.90	0.00
Agricultural Mowers	Gasoline	0.00	0.00	0.00	0.00	0.00	34.78	0.00
Agricultural Tractors	Diesel	153.85	355.56	10.47	6.92	0.00	0.00	0.00
Agricultural Tractors	Gasoline	0.00	22.22	0.00	0.00	3.46	0.00	0.00
Air Compressors	Comp. Gas	0.00	0.00	0.00	0.00	0.00	2.90	0.00
Air Compressors	Diesel	0.00	0.00	0.00	0.00	0.00	5.80	0.00
Air Compressors	Gasoline	153.85	0.00	7.85	6.92	3.46	2.90	0.00
All Terrain Vehicles	Diesel	0.00	0.00	0.00	3.46	0.00	0.00	0.00
All Terrain Vehicles	Gasoline	0.00	44.44	0.00	10.38	0.00	0.00	0.00
Chainsaws	Gasoline	3,230.77	55.56	2.62	0.00	0.00	20.29	0.00
Chippers/Stump Grinders	Diesel	0.00	0.00	2.62	0.00	0.00	0.00	0.00

Equipment Type	Fuel Type	Logging	Res-a	Res-b	Res-c	Res-d	Res-e	Res-f
Chippers/Stump Grinders	Gasoline	0.00	11.11	0.00	0.00	0.00	0.00	0.00
Crawler Tractors	Diesel	384.62	0.00	0.00	0.00	0.00	0.00	0.00
Excavators	Diesel	153.85	0.00	0.00	0.00	0.00	0.00	0.00
Industrial forklifts	Comp. Gas	0.00	22.22	128.27	124.57	76.12	40.58	100.00
Industrial forklifts	Diesel	307.69	0.00	20.94	13.84	3.46	2.90	0.00
Industrial forklifts	Gas/Propane	0.00	0.00	0.00	0.00	3.46	0.00	0.00
Industrial forklifts	Gasoline	76.92	22.22	13.09	24.22	34.60	2.90	100.00
Front/Riding Mowers	Diesel	0.00	22.22	0.00	0.00	0.00	5.80	0.00
Front/Riding Mowers	Gasoline	0.00	33.33	5.24	0.00	3.46	20.29	0.00
Generator Sets	Comp. Gas	0.00	0.00	0.00	0.00	0.00	2.90	0.00
Generator Sets	Diesel	0.00	22.22	0.00	3.46	3.46	0.00	0.00
Generator Sets	Gasoline	0.00	44.44	10.47	6.92	3.46	2.90	100.00
Golf Carts	Gasoline	0.00	0.00	2.62	3.46	0.00	0.00	0.00
Graders	Diesel	153.85	0.00	0.00	0.00	0.00	0.00	0.00
Lawn Mowers	Gasoline	0.00	11.11	0.00	0.00	0.00	2.90	0.00
Leaf Blowers/Vacuums	Gasoline	0.00	33.33	5.24	0.00	0.00	0.00	0.00
Minibikes	Gasoline	0.00	0.00	0.00	0.00	0.00	2.90	0.00
Personal Water Craft	Gasoline	0.00	0.00	0.00	0.00	6.92	0.00	0.00
Pressure Washers	Gasoline	0.00	11.11	0.00	0.00	3.46	2.90	0.00
Pumps	Diesel	0.00	22.22	0.00	0.00	0.00	0.00	0.00
Pumps	Gasoline	538.46	0.00	2.62	3.46	0.00	0.00	0.00
Rubber Tired Loaders	Diesel	384.62	66.67	10.47	0.00	3.46	0.00	0.00
Rubber Tired Loaders	Gasoline	0.00	11.11	0.00	0.00	0.00	0.00	0.00
Skid Steer Loaders	Diesel	0.00	0.00	5.24	0.00	0.00	0.00	0.00
Skidders	Diesel	538.46	0.00	0.00	0.00	0.00	0.00	0.00
Snowblowers	Gasoline	0.00	0.00	0.00	0.00	0.00	2.90	0.00
Sprayers	Gasoline	0.00	11.11	0.00	0.00	0.00	0.00	0.00
Sweepers/Scrubbers	Gasoline	0.00	11.11	0.00	0.00	0.00	0.00	0.00
Tampers/Rammers	Gasoline	0.00	11.11	0.00	0.00	0.00	0.00	0.00
Tillers	Gasoline	0.00	55.56	0.00	0.00	0.00	0.00	0.00
Tractors/Loaders/Backhoes	Diesel	0.00	22.22	10.47	0.00	0.00	43.48	0.00
Tractors/Loaders/Backhoes	Gasoline	0.00	11.11	0.00	0.00	0.00	14.49	0.00
Transport Refrigeration Units	Gasoline	0.00	0.00	340.31	0.00	0.00	0.00	0.00
Trenchers	Gasoline	0.00	11.11	0.00	0.00	0.00	0.00	0.00
Trimmers/Edgers/Brush Cutters	Gasoline	0.00	44.44	0.00	0.00	3.46	49.28	0.00
Welders	Gasoline	153.85	0.00	2.62	0.00	0.00	0.00	0.00

Application of Population Surrogates – Sector Level Equipment Totals

Tables 69 through 72 present the corresponding estimated statewide equipment totals by sector. Discussion of the reasonableness of these estimates is provided in “Statewide Equipment Population Estimates and Quality Assurance” below.

Table 69. Estimated Statewide Off-road Equipment Populations – Agricultural Sector

Equipment Category	Fuel Type	Citrus	CAFO/Dairy	Nut	Row	Tree Fruit	Vineyard/Other	Total
Aerial Lifts	Gasoline	0	0	0	0	66	0	**66**
Ag Sweepers	Diesel	0	0	743	0	66	0	**808**
Ag Sweepers	Gasoline	0	0	83	0	0	0	**83**
Agricultural Mowers	Diesel	0	186	41	0	131	23	**380**
Agricultural Mowers	Gasoline	596	0	0	214	66	23	**898**
Agricultural Tractors	Comp. Gas	0	0	41	214	0	45	**300**
Agricultural Tractors	Diesel	15,202	11,693	6,684	32,963	7,145	6,596	**80,282**
Agricultural Tractors	Gasoline	2,385	1,299	248	4,709	459	270	**9,369**
All Terrain Vehicles	Diesel	298	0	289	214	0	23	**823**
All Terrain Vehicles	Gasoline	3,875	557	454	2,997	1,311	473	**9,666**
Balancers	Diesel	0	0	165	0	0	0	**165**
Bale Haulers	Diesel	0	0	0	0	0	23	**23**
Balers	Diesel	0	371	248	1,498	0	135	**2,252**
Balers	Gasoline	0	0	0	0	0	23	**23**
Chainsaws	Gasoline	596	0	0	0	0	0	**596**
Combines	Comp. Gas	0	0	83	0	0	0	**83**
Combines	Diesel	0	0	248	856	721	0	**1,825**
Combines	Gasoline	0	0	124	0	66	0	**189**
Cranes	Diesel	0	0	0	0	0	68	**68**
Cranes	Gasoline	0	0	0	0	0	23	**23**
Crawler Tractors	Gasoline	0	186	0	0	0	0	**186**
Excavators	Diesel	0	0	0	0	0	23	**23**
Excavators	Gasoline	0	0	41	0	0	0	**41**
Industrial forklifts	Comp. Gas	596	0	83	214	131	315	**1,339**
Industrial forklifts	Diesel	596	0	41	0	262	45	**945**
Industrial forklifts	Gasoline	0	0	124	214	66	23	**426**
Front/Riding Mowers	Gasoline	0	0	0	0	0	23	**23**
Generator Sets	Diesel	0	0	0	0	0	45	**45**
Generator Sets	Gasoline	0	186	0	0	0	23	**208**
Irrigation Sets	Diesel	0	0	0	428	0	0	**428**
Lawn Mowers	Gasoline	298	0	0	428	66	45	**837**
Leaf Blowers/Vacuums	Gasoline	298	0	0	0	0	0	**298**

Equipment Category	Fuel Type	Citrus	CAFO/Dairy	Nut	Row	Tree Fruit	Vineyard/Other	Total
Pruning Towers	Diesel	0	0	0	214	0	0	**214**
Pruning Towers	Gasoline	0	0	0	214	0	0	**214**
Pumps	Diesel	298	186	124	0	0	0	**607**
Pumps	Gasoline	0	0	0	0	0	23	**23**
Rubber Tired Loaders	Diesel	298	371	83	0	0	68	**819**
Rubber Tired Loaders	Gasoline	0	0	124	0	0	0	**124**
Shakers	Diesel	0	0	454	0	0	0	**454**
Shredders	Gasoline	0	0	0	0	0	23	**23**
Skid Steer Loaders	Diesel	0	186	0	0	0	0	**186**
Sprayers	Diesel	1,192	0	330	0	0	203	**1,725**
Sprayers	Gasoline	1,490	0	248	1,498	721	45	**4,002**
Spreaders	Comp. Gas	0	0	0	0	0	90	**90**
Swathers	Diesel	0	371	41	642	0	68	**1,122**
Swathers	Gasoline	0	0	41	0	0	0	**41**
Tillers	Gasoline	298	0	0	642	0	0	**940**
Tractors/Loaders/Backhoes	Diesel	596	186	83	428	66	45	**1,403**
Trenchers	Diesel	0	0	0	0	0	23	**23**
Trenchers	Gasoline	298	0	0	0	0	0	**298**
Trimmers/Edgers/Brush Cutters	Gasoline	298	0	0	0	197	45	**540**
Welders	Comp. Gas	0	0	0	214	0	0	**214**
Welders	Gasoline	298	0	0	0	0	0	**298**
Wood Splitters	Gasoline	298	0	0	0	66	0	**364**
Total		**30,104**	**15,778**	**11,268**	**49,015**	**11,606**	**8,900**	**126,659**

Table 70. Estimated Statewide Off-road Equipment Populations – Construction/Mining Sector

Equipment Type	Fuel Type	Cons-a	Cons-b	Cons-c	Mining	Total
Aerial Lifts	Comp. Gas	128	0	0	0	**128**
Aerial Lifts	Diesel	128	0	102	0	**230**
Air Compressors	Comp. Gas	0	0	204	0	**204**
Air Compressors	Diesel	895	321	1,632	0	**2,848**
Air Compressors	Gasoline	384	856	4,487	40	**5,766**
Bore/Drill Rigs	Diesel	0	0	1,020	0	**1,020**

Equipment Type	Fuel Type	Cons-a	Cons-b	Cons-c	Mining	Total
Bore/Drill Rigs	Gasoline	0	0	306	0	**306**
Cement and Mortar Mixers	Diesel	128	0	0	0	**128**
Cement and Mortar Mixers	Gasoline	0	0	306	0	**306**
Chippers/Stump Grinders	Diesel	0	0	0	8	**8**
Concrete/Industrial Saws	Gasoline	0	0	510	0	**510**
Cranes	Diesel	0	0	306	0	**306**
Crawler Tractors	Diesel	0	321	306	0	**627**
Crawler Tractors	Gasoline	0	0	0	8	**8**
Excavators	Diesel	0	1,177	510	16	**1,702**
Industrial forklifts	Comp. Gas	0	321	816	168	**1,304**
Industrial forklifts	Diesel	0	0	816	0	**816**
Industrial forklifts	Gasoline	128	0	102	0	**230**
Front/Riding Mowers	Gasoline	384	0	0	0	**384**
Generator Sets	Comp. Gas	0	0	102	0	**102**
Generator Sets	Diesel	0	0	510	0	**510**
Generator Sets	Gasoline	1,791	535	5,813	32	**8,170**
Graders	Diesel	0	642	204	8	**854**
Hydro Power Units	Gasoline	0	0	102	0	**102**
Leaf Blowers/Vacuums	Gasoline	128	0	0	0	**128**
Materials Handling (Other)	Diesel	0	0	0	8	**8**
Pavers	Diesel	0	107	0	0	**107**
Paving Equipment	Gasoline	128	0	0	0	**128**
Pipe Threader	Gasoline	0	0	204	0	**204**
Plate Compactors	Diesel	0	107	0	0	**107**
Pressure Washers	Gasoline	256	0	1,530	0	**1,785**
Pumps	Diesel	128	0	102	0	**230**
Pumps	Gasoline	0	0	612	0	**612**
Rollers	Diesel	0	642	1,020	0	**1,662**
Rollers	Gasoline	0	107	306	0	**413**
Rubber Tired Loaders	Diesel	256	1,177	714	64	**2,210**
Scrapers	Diesel	0	214	0	8	**222**
Signal Boards	Diesel	0	0	102	0	**102**
Skid Steer Loaders	Diesel	384	535	2,040	8	**2,966**
Snowmobiles	Gasoline	0	0	306	0	**306**

Equipment Type	Fuel Type	Cons-a	Cons-b	Cons-c	Mining	Total
Sprayers	Diesel	0	0	102	0	**102**
Sprayers	Dual Gas/Electric	0	0	306	0	**306**
Sprayers	Gasoline	128	0	510	0	**638**
Storm Grinder	Diesel	0	0	0	8	**8**
Storm Grinder	Gasoline	0	0	0	8	**8**
Tillers	Gasoline	0	0	102	0	**102**
Tractors/Loaders/Backhoes	Comp. Gas	0	214	0	0	**214**
Tractors/Loaders/Backhoes	Diesel	767	1,711	6,425	56	**8,959**
Tractors/Loaders/Backhoes	Gasoline	0	0	102	0	**102**
Trenchers	Gasoline	0	0	102	0	**102**
Trimmers/Edgers/Brush Cutters	Gasoline	0	214	204	0	**418**
Vacuum	Gasoline	0	0	510	0	**510**
Vessels w/Outboard Engines	Gasoline	0	107	0	0	**107**
Welders	Diesel	0	0	102	8	**110**
Welders	Gasoline	0	0	306	8	**314**
Total		**5,885**	**9,308**	**33,555**	**456**	**49,197**

Table 71. Estimated Statewide Off-road Equipment Populations – Residential Sector

Equipment Type	Fuel Type	Target	Other Areas	Total
Agricultural Tractors	Diesel	2,855	8,334	**11,189**
Agricultural Tractors	Gasoline	4,283	83,337	**87,619**
All Terrain Vehicles	Diesel	0	8,334	**8,334**
All Terrain Vehicles	Gasoline	8,565	50,002	**58,567**
Cement and Mortar Mixers	Gasoline	1,428	0	**1,428**
Chainsaws	Gasoline	49,964	383,348	**433,312**
Chippers/Stump Grinders	Gasoline	1,428	25,001	**26,429**
Front/Riding Mowers	Gasoline	17,131	141,672	**158,803**
Generator Sets	Gasoline	5,710	25,001	**30,711**
Golf Carts	Gasoline	1,428	16,667	**18,095**
Graders	Diesel	1,428	0	**1,428**
Lawn Mowers	Gasoline	87,081	1,366,719	**1,453,799**
Leaf Blowers/Vacuums	Gasoline	15,703	175,007	**190,710**
Minibikes	Gasoline	0	8,334	**8,334**

Equipment Type	Fuel Type	Target	Other Areas	Total
Off-Road Motorcycles Active	Gasoline	7,138	116,671	**123,809**
Personal Water Craft	Gasoline	0	25,001	**25,001**
Pressure Washers	Gasoline	2,855	25,001	**27,856**
Shredders	Gasoline	4,283	16,667	**20,950**
Snowblowers	Gasoline	7,138	0	**7,138**
Snowmobiles Active	Gasoline	1,428	0	**1,428**
Specialty Vehicles Carts	Gasoline	0	16,667	**16,667**
Sprayers	Gasoline	1,428	0	**1,428**
Tillers	Gasoline	2,855	83,337	**86,192**
Trimmers/Edgers/Brush Cutters	Comp. Gas	1,428	8,334	**9,761**
Trimmers/Edgers/Brush Cutters	Gasoline	41,399	500,019	**541,418**
Vessels w/Outboard Engines	Diesel	0	8,334	**8,334**
Vessels w/Outboard Engines	Gasoline	7,138	16,667	**23,805**
Total		**274,089**	**3,108,452**	**3,382,541**

Table 72. Estimated Statewide Off-road Equipment Populations – Residual Sector

Equipment Type	Fuel Type	Logging	Res-a	Res-b	Res-c	Res-d	Res-e	Res-f	Total
Ag Sweeper	Diesel	0	242	0	0	0	0	0	**242**
Agricultural Mowers	Diesel	0	0	0	0	0	397	0	**397**
Agricultural Mowers	Gasoline	0	0	0	0	0	4,765	0	**4,765**
Agricultural Tractors	Diesel	47	7,752	1,605	800	0	0	0	**10,204**
Agricultural Tractors	Gasoline	0	484	0	0	418	0	0	**902**
Air Compressors	Comp. Gas	0	0	0	0	0	397	0	**397**
Air Compressors	Diesel	0	0	0	0	0	794	0	**794**
Air Compressors	Gasoline	47	0	1,204	800	0	397	0	**2,448**
All Terrain Vehicles	Diesel	0	0	0	400	0	0	0	**400**
All Terrain Vehicles	Gasoline	0	969	0	1,201	0	0	0	**2,170**
Chainsaws	Gasoline	992	1,211	401	0	0	2,780	0	**5,384**
Chippers/Stump Grinders	Diesel	0	0	401	0	0	0	0	**401**
Chippers/Stump Grinders	Gasoline	0	242	0	0	0	0	0	**242**
Crawler Tractors	Diesel	118	0	0	0	0	0	0	**118**
Excavators	Diesel	47	0	0	0	0	0	0	**47**
Industrial forklifts	Comp. Gas	0	484	19,659	14,407	9,195	5,559	943	**50,247**

Equipment Type	Fuel Type	Logging	Res-a	Res-b	Res-c	Res-d	Res-e	Res-f	Total
Industrial forklifts	Diesel	94	0	3,210	1,601	418	397	0	**5,720**
Industrial forklifts	Gas/Propane	0	0	0	0	418	0	0	**418**
Industrial forklifts	Gasoline	24	484	2,006	2,801	4,180	397	943	**10,835**
Front/Riding Mowers	Diesel	0	484	0	0	0	794	0	**1,278**
Front/Riding Mowers	Gasoline	0	727	802	0	418	2,780	0	**4,727**
Generator Sets	Comp. Gas	0	0	0	0	0	397	0	**397**
Generator Sets	Diesel	0	484	0	400	418	0	0	**1,302**
Generator Sets	Gasoline	0	969	1,605	800	418	397	943	**5,132**
Golf Carts	Gasoline	0	0	401	400	0	0	0	**801**
Graders	Diesel	47	0	0	0	0	0	0	**47**
Lawn Mowers	Gasoline	0	242	0	0	0	397	0	**639**
Leaf Blowers/Vacuums	Gasoline	0	727	802	0	0	0	0	**1,529**
Minibikes	Gasoline	0	0	0	0	0	397	0	**397**
Personal Water Craft	Gasoline	0	0	0	0	836	0	0	**836**
Pressure Washers	Gasoline	0	242	0	0	418	397	0	**1,057**
Pumps	Diesel	0	484	0	0	0	0	0	**484**
Pumps	Gasoline	165	0	401	400	0	0	0	**966**
Rubber Tired Loaders	Diesel	118	1,453	1,605	0	418	0	0	**3,594**
Rubber Tired Loaders	Gasoline	0	242	0	0	0	0	0	**242**
Skid Steer Loaders	Diesel	0	0	802	0	0	0	0	**802**
Skidders	Diesel	165	0	0	0	0	0	0	**165**
Snowblowers	Gasoline	0	0	0	0	0	397	0	**397**
Sprayers	Gasoline	0	242	0	0	0	0	0	**242**
Sweepers/Scrubbers	Gasoline	0	242	0	0	0	0	0	**242**
Tampers/Rammers	Gasoline	0	242	0	0	0	0	0	**242**
Tillers	Gasoline	0	1,211	0	0	0	0	0	**1,211**
Tractors/Loaders/Backhoes	Diesel	0	484	1,605	0	0	5,957	0	**8,046**
Tractors/Loaders/Backhoes	Gasoline	0	242	0	0	0	1,986	0	**2,228**
Transport Refrigeration Units	Gasoline	0	0	52,157	0	0	0	0	**52,157**
Trenchers	Gasoline	0	242	0	0	0	0	0	**242**
Trimmers/Edgers/Brush Cutters	Gasoline	0	969	0	0	418	6,751	0	**8,138**
Welders	Gasoline	47	0	401	0	0	0	0	**448**
Total		**1,911**	**21,796**	**89,067**	**24,010**	**17,973**	**36,533**	**2,829**	**194,119**

County Allocation Factors

Once statewide populations were developed for each sector, selected surrogates were applied to allocate populations to the county level. County-level acreage and head counts compiled from the 2002 Agricultural Census are shown in Table 73, along with the corresponding allocation fractions. These fractions can be applied directly to the statewide equipment totals in Table 69 to obtain county-level population estimates for the Agricultural sector. Note that these surrogate data are for 2002 production, and may need to be updated once 2007 production data becomes available.

County-level establishment counts were not readily available for the Construction and Mining or Residual sectors. Therefore county-level employment data obtained from the CREE data set for 2005 were used to geographically allocate statewide equipment population totals for these sectors. County-level employment surrogates and corresponding allocation factors are provided for the Construction and Mining sector in Table 74, and for the Residual sector in Table 75. If substantial employment shifts have occurred between 2005 and 2007, these factors may merit adjustment.

Table 76 presents county-level household counts, the surrogate for the Residential sector. Note that counties located in the "target" stratum are listed in bold. As noted above, these data are for 2006 and would need to be adjusted if significant population shifts took place in 2007.

Table 73. County Level Equipment Population Surrogates and Allocation Factors - Agricultural Sector

County	Citrus (acres)	Fraction	Dairy/ CAFO (#head)*	Fraction	Nut Crop (acres)	Fraction	Row Crop (acres)	Fraction	Tree Crop (acres)	Fraction	Vineyard/ Other (acres)	Fraction
Alameda	0	0.000	19,812	0.004	3	0.000	3,936	0.000	129	0.000	2,414	0.002
Alpine	0	0.000	2,111	0.000	0	0.000	850	0.000	0	0.000	0	0.000
Amador	0	0.000	19,236	0.004	652	0.001	1,476	0.000	23	0.000	3,696	0.004
Butte	621	0.001	19,431	0.004	90,300	0.081	201,893	0.024	30,256	0.046	302	0.000
Calaveras	0	0.000	27,490	0.006	684	0.001	1,231	0.000	269	0.000	578	0.001
Colusa	0	0.000	16,922	0.004	32,268	0.029	447,385	0.054	2,494	0.004	0	0.000
Contra Costa	0	0.000	20,779	0.005	1,130	0.001	30,152	0.004	2,738	0.004	1,817	0.002
Del Norte	0	0.000	9,875	0.002	0	0.000	2,710	0.000	0	0.000	0	0.000
El Dorado	40	0.000	7,675	0.002	435	0.000	571	0.000	1,683	0.003	2,224	0.002
Fresno	113,997	0.123	396,519	0.087	119,342	0.108	802,704	0.097	94,969	0.144	238,136	0.239
Glenn	2,464	0.003	65,397	0.014	46,838	0.042	260,672	0.032	26,054	0.040	3,335	0.003
Humboldt	0	0.000	63,106	0.014	28	0.000	15,745	0.002	222	0.000	169	0.000
Imperial	10,953	0.012	392,026	0.086	21	0.000	637,004	0.077	1,606	0.002	54,334	0.055
Inyo	0	0.000	17,897	0.004	0	0.000	3,085	0.000	0	0.000	0	0.000
Kern	173,052	0.186	260,040	0.057	167,733	0.151	489,791	0.059	21,766	0.033	96,510	0.097
Kings	236	0.000	269,530	0.059	29,874	0.027	265,081	0.032	12,828	0.019	4,581	0.005
Lake	0	0.000	9,146	0.002	5,557	0.005	3,736	0.000	6,512	0.010	9,437	0.009
Lassen	0	0.000	49,324	0.011	0	0.000	42,859	0.005	18	0.000	328	0.000
Los Angeles	606	0.001	5,063	0.001	60	0.000	24,815	0.003	1,836	0.003	709	0.001
Madera	13,751	0.015	146,781	0.032	84,948	0.077	118,837	0.014	18,227	0.028	84,173	0.085
Marin	4	0.000	35,412	0.008	12	0.000	4,613	0.001	5	0.000	117	0.000
Mariposa	0	0.000	22,579	0.005	1	0.000	472	0.000	45	0.000	71	0.000
Mendocino	0	0.000	20,024	0.004	34	0.000	9,025	0.001	6,156	0.009	17,792	0.018
Merced	697	0.001	465,107	0.102	115,921	0.105	397,117	0.048	17,086	0.026	13,929	0.014
Modoc	0	0.000	75,193	0.017	0	0.000	113,482	0.014	0	0.000	366	0.000
Mono	0	0.000	5,927	0.001	0	0.000	13,112	0.002	0	0.000	0	0.000
Monterey	1,526	0.002	73,061	0.016	742	0.001	967,562	0.117	523	0.001	55,287	0.056
Napa	11	0.000	7,998	0.002	273	0.000	2,249	0.000	130	0.000	49,895	0.050
Nevada	0	0.000	5,042	0.001	21	0.000	2,291	0.000	114	0.000	525	0.001
Orange	1,139	0.001	793	0.000	0	0.000	5,974	0.001	6	0.000	2,392	0.002

County	Citrus (acres)	Fraction	Dairy/ CAFO (#head)*	Fraction	Nut Crop (acres)	Fraction	Row Crop (acres)	Fraction	Tree Crop (acres)	Fraction	Vineyard/ Other (acres)	Fraction
Placer	594	0.001	20,991	0.005	284	0.000	33,857	0.004	988	0.001	436	0.000
Plumas	0	0.000	16,417	0.004	6	0.000	9,048	0.001	0	0.000	0	0.000
Riverside	79,965	0.086	181,071	0.040	102	0.000	195,722	0.024	12,537	0.019	15,398	0.015
Sacramento	89	0.000	67,536	0.015	618	0.001	120,448	0.015	14,965	0.023	21,364	0.021
San Benito	0	0.000	236	0.000	2,911	0.003	78,521	0.010	3,569	0.005	2,605	0.003
San Bernardino	14,037	0.015	279	0.000	799	0.001	32,743	0.004	1,670	0.003	1,049	0.001
San Diego	42,563	0.046	232	0.000	161	0.000	28,632	0.003	27,113	0.041	1,094	0.001
San Francisco	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
San Joaquin	429	0.000	697	0.000	86,775	0.078	517,332	0.063	28,356	0.043	79,488	0.080
San Luis Obispo	4,406	0.005	709	0.000	6,398	0.006	147,442	0.018	3,722	0.006	26,170	0.026
San Mateo	0	0.000	48	0.000	0	0.000	10,011	0.001	30	0.000	168	0.000
Santa Barbara	6,867	0.007	260	0.000	1,512	0.001	215,067	0.026	9,052	0.014	31,443	0.032
Santa Clara	0	0.000	25,069	0.006	508	0.000	33,157	0.004	2,136	0.003	2,411	0.002
Santa Cruz	40	0.000	3,435	0.001	18	0.000	67,046	0.008	4,447	0.007	5,759	0.006
Shasta	46	0.000	28,405	0.006	537	0.000	18,891	0.002	222	0.000	120	0.000
Sierra	0	0.000	7,116	0.002	0	0.000	2,800	0.000	0	0.000	0	0.000
Siskiyou	0	0.000	64,689	0.014	0	0.000	126,073	0.015	54	0.000	35	0.000
Solano	209	0.000	45,112	0.010	12,008	0.011	143,596	0.017	7,187	0.011	3,632	0.004
Sonoma	34	0.000	81,598	0.018	218	0.000	25,244	0.003	4,372	0.007	59,207	0.060
Stanislaus	5,455	0.006	425,945	0.094	139,482	0.126	284,215	0.034	20,693	0.031	11,582	0.012
Sutter	67	0.000	10,326	0.002	33,523	0.030	325,361	0.039	74,425	0.113	1,145	0.001
Tehama	86	0.000	68,195	0.015	26,310	0.024	25,101	0.003	28,597	0.043	285	0.000
Trinity	0	0.000	4,935	0.001	8	0.000	501	0.000	66	0.000	155	0.000
Tulare	352,658	0.380	900,124	0.198	62,454	0.056	348,796	0.042	107,230	0.163	64,770	0.065
Tuolumne	0	0.000	12,251	0.003	0	0.000	475	0.000	165	0.000	44	0.000
Ventura	100,300	0.108	8,918	0.002	218	0.000	99,147	0.012	20,273	0.031	8,776	0.009
Yolo	813	0.001	16,909	0.004	23,794	0.021	421,350	0.051	7,051	0.011	14,287	0.014
Yuba	144	0.000	31,438	0.007	13,463	0.012	74,726	0.009	34,352	0.052	142	0.000
Statewide	**927,899**		**4,552,237**		**1,108,984**		**8,255,732**		**658,967**		**994,682**	

* From cattle and cows inventory totals

Table 74. County Level Equipment Population Surrogates (# Employees) and Allocation Factors – Construction/Mining Sector

County	Cons-a	Fraction	Cons-b	Fraction	Cons-c	Fraction	Mining	Fraction
Alameda	10,117	0.0473	4,938	0.0438	28,012	0.0498	41	0.0117
Alpine	61	0.0003	0	0.0000	20	0.0000	0	0.0000
Amador	256	0.0012	158	0.0014	496	0.0009	71	0.0205
Butte	1,082	0.0051	543	0.0048	2,608	0.0046	30	0.0088
Calaveras	662	0.0031	169	0.0015	749	0.0013	10	0.0029
Colusa	44	0.0002	30	0.0003	152	0.0003	10	0.0029
Contra Costa	8,611	0.0403	7,360	0.0652	13,110	0.0233	102	0.0293
Del Norte	135	0.0006	102	0.0009	194	0.0003	10	0.0029
El Dorado	1,374	0.0064	631	0.0056	3,677	0.0065	41	0.0117
Fresno	4,909	0.0230	2,844	0.0252	13,517	0.0241	0	0.0000
Glenn	78	0.0004	61	0.0005	233	0.0004	10	0.0029
Humboldt	1,256	0.0059	361	0.0032	1,425	0.0025	10	0.0029
Imperial	278	0.0013	339	0.0030	1,243	0.0022	20	0.0059
Inyo	151	0.0007	71	0.0006	341	0.0006	30	0.0088
Kern	3,180	0.0149	3,786	0.0336	10,133	0.0180	202	0.0582
Kings	282	0.0013	132	0.0012	851	0.0015	0	0.0000
Lake	299	0.0014	133	0.0012	697	0.0012	30	0.0088
Lassen	160	0.0008	71	0.0006	256	0.0005	20	0.0059
Los Angeles	35,538	0.1662	16,870	0.1495	94,919	0.1689	544	0.1568
Madera	861	0.0040	347	0.0031	1,686	0.0030	20	0.0059
Marin	4,431	0.0207	461	0.0041	3,702	0.0066	10	0.0029
Mariposa	87	0.0004	71	0.0006	215	0.0004	20	0.0059
Mendocino	890	0.0042	320	0.0028	861	0.0015	30	0.0088
Merced	867	0.0041	307	0.0027	1,852	0.0033	10	0.0029
Modoc	49	0.0002	71	0.0006	83	0.0001	10	0.0029
Mono	287	0.0013	30	0.0003	406	0.0007	0	0.0000
Monterey	1,949	0.0091	428	0.0038	4,485	0.0080	51	0.0146
Napa	1,123	0.0053	493	0.0044	2,434	0.0043	30	0.0088
Nevada	1,511	0.0071	349	0.0031	2,156	0.0038	41	0.0117
Orange	23,567	0.1102	9,233	0.0818	66,733	0.1187	145	0.0418
Placer	4,301	0.0201	1,570	0.0139	10,676	0.0190	51	0.0146

County	Cons-a	Fraction	Cons-b	Fraction	Cons-c	Fraction	Mining	Fraction
Plumas	332	0.0016	47	0.0004	539	0.0010	20	0.0059
Riverside	12,344	0.0577	9,391	0.0832	56,161	0.0999	163	0.0468
Sacramento	7,853	0.0367	6,070	0.0538	30,796	0.0548	51	0.0146
San Benito	349	0.0016	122	0.0011	1,359	0.0024	10	0.0029
San Bernardino	7,784	0.0364	7,311	0.0648	29,905	0.0532	405	0.1167
San Diego	22,212	0.1039	12,261	0.1086	55,625	0.0990	152	0.0439
San Francisco	6,757	0.0316	1,189	0.0105	8,038	0.0143	10	0.0029
San Joaquin	2,891	0.0135	2,457	0.0218	10,317	0.0184	178	0.0512
San Luis Obispo	3,120	0.0146	797	0.0071	4,571	0.0081	71	0.0205
San Mateo	5,801	0.0271	1,014	0.0090	9,267	0.0165	51	0.0146
Santa Barbara	2,482	0.0116	1,247	0.0111	6,412	0.0114	61	0.0176
Santa Clara	10,028	0.0469	4,636	0.0411	28,089	0.0500	51	0.0146
Santa Cruz	2,416	0.0113	1,064	0.0094	3,383	0.0060	30	0.0088
Shasta	1,378	0.0064	1,072	0.0095	2,830	0.0050	81	0.0234
Sierra	50	0.0002	30	0.0003	51	0.0001	10	0.0029
Siskiyou	373	0.0017	120	0.0011	458	0.0008	20	0.0059
Solano	4,179	0.0195	1,530	0.0136	7,137	0.0127	10	0.0029
Sonoma	3,889	0.0182	2,233	0.0198	8,619	0.0153	96	0.0278
Stanislaus	2,614	0.0122	1,878	0.0166	9,056	0.0161	30	0.0088
Sutter	416	0.0019	251	0.0022	1,026	0.0018	10	0.0029
Tehama	240	0.0011	143	0.0013	543	0.0010	10	0.0029
Trinity	80	0.0004	29	0.0003	115	0.0002	10	0.0029
Tulare	1,578	0.0074	1,187	0.0105	3,957	0.0070	30	0.0088
Tuolumne	570	0.0027	159	0.0014	953	0.0017	30	0.0088
Ventura	4,181	0.0196	3,079	0.0273	11,083	0.0197	194	0.0559
Yolo	1,343	0.0063	1,109	0.0098	3,154	0.0056	41	0.0117
Yuba	147	0.0007	142	0.0013	675	0.0012	41	0.0117
Total	**213,808**		**112,850**		**562,039**		**3,471**	

Table 75. County Level Equipment Population Surrogates (# Employees) and Allocation Factors – Residual Sector

County	Logging	Fraction	Res-a	Fraction	Res-b	Fraction	Res-c	Fraction	Res-d	Fraction	Res-e	Fraction	Res-f	Fraction
Alameda	0	0.0000	105	0.0051	98,440	0.0481	41,268	0.0606	51,957	0.0437	34,476	0.0361	131,830	0.0538
Alpine	0	0.0000	0	0.0000	20	0.0000	0	0.0000	30	0.0000	122	0.0001	244	0.0001
Amador	41	0.0160	20	0.0010	923	0.0005	355	0.0005	1,045	0.0009	531	0.0006	5,271	0.0022
Butte	47	0.0184	122	0.0059	4,709	0.0023	2,095	0.0031	8,161	0.0069	2,873	0.0030	16,860	0.0069
Calaveras	102	0.0400	20	0.0010	922	0.0005	230	0.0003	1,074	0.0009	701	0.0007	2,529	0.0010
Colusa	0	0.0000	0	0.0000	559	0.0003	461	0.0007	378	0.0003	219	0.0002	1,991	0.0008
Contra Costa	0	0.0000	237	0.0116	25,783	0.0126	10,334	0.0152	33,599	0.0282	17,628	0.0185	50,985	0.0208
Del Norte	20	0.0080	155	0.0076	406	0.0002	122	0.0002	479	0.0004	509	0.0005	3,646	0.0015
El Dorado	99	0.0388	50	0.0024	3,038	0.0015	1,447	0.0021	4,737	0.0040	3,875	0.0041	9,445	0.0039
Fresno	34	0.0132	520	0.0254	28,505	0.0139	13,444	0.0198	27,576	0.0232	11,460	0.0120	68,048	0.0278
Glenn	0	0.0000	10	0.0005	691	0.0003	400	0.0006	484	0.0004	355	0.0004	2,458	0.0010
Humboldt	414	0.1631	461	0.0225	4,845	0.0024	1,179	0.0017	4,765	0.0040	2,469	0.0026	13,508	0.0055
Imperial	0	0.0000	55	0.0027	2,711	0.0013	1,989	0.0029	6,101	0.0051	1,259	0.0013	17,063	0.0070
Inyo	0	0.0000	0	0.0000	578	0.0003	168	0.0002	672	0.0006	1,064	0.0011	3,362	0.0014
Kern	20	0.0080	493	0.0240	17,590	0.0086	7,205	0.0106	22,583	0.0190	6,948	0.0073	56,673	0.0231
Kings	0	0.0000	20	0.0010	1,841	0.0009	632	0.0009	3,326	0.0028	972	0.0010	13,914	0.0057
Lake	10	0.0040	10	0.0005	922	0.0005	339	0.0005	1,686	0.0014	1,049	0.0011	4,418	0.0018
Lassen	135	0.0532	61	0.0030	504	0.0002	142	0.0002	658	0.0006	389	0.0004	6,023	0.0025
Los Angeles	41	0.0160	3,241	0.1582	718,247	0.3512	236,756	0.3479	306,735	0.2579	370,722	0.3883	592,829	0.2418
Madera	8	0.0032	47	0.0023	2,075	0.0010	819	0.0012	2,819	0.0024	1,138	0.0012	10,055	0.0041
Marin	0	0.0000	81	0.0040	8,073	0.0039	3,182	0.0047	9,461	0.0080	7,680	0.0080	14,930	0.0061
Mariposa	20	0.0080	0	0.0000	376	0.0002	81	0.0001	355	0.0003	1,831	0.0019	1,940	0.0008
Mendocino	306	0.1204	370	0.0180	3,297	0.0016	1,152	0.0017	3,501	0.0029	2,587	0.0027	7,546	0.0031
Merced	10	0.0040	64	0.0031	4,602	0.0023	1,300	0.0019	6,272	0.0053	1,941	0.0020	14,321	0.0058
Modoc	20	0.0080	10	0.0005	163	0.0001	91	0.0001	203	0.0002	109	0.0001	1,422	0.0006
Mono	0	0.0000	10	0.0005	277	0.0001	71	0.0001	379	0.0003	2,245	0.0024	1,513	0.0006
Monterey	0	0.0000	870	0.0425	9,720	0.0048	5,288	0.0078	12,063	0.0101	12,721	0.0133	30,774	0.0126
Napa	0	0.0000	61	0.0030	10,729	0.0052	1,874	0.0028	3,854	0.0032	4,865	0.0051	10,156	0.0041
Nevada	81	0.0320	11	0.0005	2,186	0.0011	949	0.0014	3,034	0.0026	2,443	0.0026	5,515	0.0022
Orange	10	0.0040	1,929	0.0941	226,534	0.1108	91,121	0.1339	112,211	0.0943	95,507	0.1000	157,729	0.0643
Placer	10	0.0040	245	0.0119	7,432	0.0036	3,115	0.0046	16,084	0.0135	9,120	0.0096	20,313	0.0083

County	Logging	Fraction	Res-a	Fraction	Res-b	Fraction	Res-c	Fraction	Res-d	Fraction	Res-e	Fraction	Res-f	Fraction
Plumas	81	0.0320	41	0.0020	650	0.0003	184	0.0003	736	0.0006	669	0.0007	2,539	0.0010
Riverside	0	0.0000	1,300	0.0635	63,989	0.0313	20,008	0.0294	64,315	0.0541	36,796	0.0385	104,408	0.0426
Sacramento	20	0.0080	173	0.0084	40,619	0.0199	19,400	0.0285	49,755	0.0418	21,827	0.0229	160,877	0.0656
San Benito	0	0.0000	30	0.0015	1,485	0.0007	477	0.0007	1,010	0.0008	491	0.0005	3,047	0.0012
San Bernardino	51	0.0200	395	0.0193	98,947	0.0484	33,455	0.0492	63,778	0.0536	27,729	0.0290	119,541	0.0488
San Diego	0	0.0000	4,169	0.2035	176,416	0.0863	48,476	0.0712	105,778	0.0889	83,904	0.0879	218,464	0.0891
San Francisco	0	0.0000	51	0.0025	41,552	0.0203	13,770	0.0202	21,192	0.0178	45,489	0.0476	83,892	0.0342
San Joaquin	0	0.0000	173	0.0084	26,165	0.0128	8,869	0.0130	20,825	0.0175	7,519	0.0079	40,219	0.0164
San Luis Obispo	0	0.0000	193	0.0094	7,997	0.0039	3,405	0.0050	10,407	0.0087	6,855	0.0072	22,141	0.0090
San Mateo	0	0.0000	164	0.0080	55,933	0.0274	12,867	0.0189	22,406	0.0188	19,270	0.0202	32,602	0.0133
Santa Barbara	0	0.0000	243	0.0118	15,932	0.0078	5,129	0.0075	14,709	0.0124	11,783	0.0123	36,969	0.0151
Santa Clara	10	0.0040	278	0.0136	211,772	0.1036	39,270	0.0577	48,920	0.0411	34,675	0.0363	94,353	0.0385
Santa Cruz	51	0.0200	247	0.0120	6,300	0.0031	3,859	0.0057	8,364	0.0070	4,944	0.0052	21,633	0.0088
Shasta	373	0.1467	538	0.0263	4,243	0.0021	2,115	0.0031	7,939	0.0067	3,167	0.0033	13,203	0.0054
Sierra	41	0.0160	10	0.0005	71	0.0000	30	0.0000	91	0.0001	66	0.0001	427	0.0002
Siskiyou	153	0.0604	104	0.0051	1,406	0.0007	424	0.0006	1,398	0.0012	1,027	0.0011	3,951	0.0016
Solano	0	0.0000	71	0.0035	8,768	0.0043	4,304	0.0063	13,907	0.0117	5,256	0.0055	25,899	0.0106
Sonoma	30	0.0120	374	0.0182	24,261	0.0119	7,295	0.0107	18,861	0.0159	11,914	0.0125	30,875	0.0126
Stanislaus	10	0.0040	977	0.0477	15,204	0.0074	5,616	0.0083	17,680	0.0149	5,724	0.0060	26,000	0.0106
Sutter	10	0.0040	51	0.0025	1,693	0.0008	865	0.0013	3,615	0.0030	1,146	0.0012	4,469	0.0018
Tehama	112	0.0440	91	0.0045	1,042	0.0005	438	0.0006	1,587	0.0013	673	0.0007	4,306	0.0018
Trinity	28	0.0112	10	0.0005	326	0.0002	41	0.0001	295	0.0002	308	0.0003	1,463	0.0006
Tulare	20	0.0080	337	0.0165	10,785	0.0053	4,487	0.0066	11,046	0.0093	3,228	0.0034	30,368	0.0124
Tuolumne	101	0.0396	30	0.0015	1,495	0.0007	607	0.0009	1,490	0.0013	1,196	0.0013	5,525	0.0023
Ventura	0	0.0000	1,077	0.0526	30,795	0.0151	13,364	0.0196	27,115	0.0228	15,654	0.0164	42,860	0.0175
Yolo	10	0.0040	71	0.0035	9,323	0.0046	3,869	0.0057	4,947	0.0042	3,192	0.0033	36,969	0.0151
Yuba	10	0.0040	10	0.0005	1,060	0.0005	295	0.0004	1,006	0.0008	420	0.0004	7,109	0.0029
Total	**2,540**		**20,485**		**2,044,925**		**680,528**		**1,189,456**		**954,730**		**2,451,421**	

Table 76. County Level Equipment Population Surrogates (# Households) and Allocation Factors – Residential Sector

County	# Households	Fraction
Alameda	516,035	0.0425
Alpine	1,575	0.0001
Amador	15,781	0.0013
Butte	86,436	0.0071
Calaveras	24,603	0.0020
Colusa	6,792	0.0006
Contra Costa	358,750	0.0295
Del Norte	10,110	0.0008
El Dorado	**75,390**	**0.0062**
Fresno	276,233	0.0227
Glenn	9,742	0.0008
Humboldt	53,989	0.0044
Imperial	**47,565**	**0.0039**
Inyo	8,369	0.0007
Kern	242,127	0.0199
Kings	37,850	0.0031
Lake	**31,824**	**0.0026**
Lassen	11,723	0.0010
Los Angeles	3,094,557	0.2548
Madera	43,954	0.0036
Marin	99,563	0.0082
Mariposa	8,929	0.0007
Mendocino	35,649	0.0029
Merced	**74,739**	**0.0062**
Modoc	4,451	0.0004
Mono	12,334	0.0010
Monterey	127,911	0.0105
Napa	**48,645**	**0.0040**
Nevada	45,415	0.0037
Orange	943,148	0.0776

County	# Households	Fraction
Placer	**131,068**	**0.0108**
Plumas	13,595	0.0011
Riverside	675,317	0.0556
Sacramento	500,184	0.0412
San Benito	16,434	0.0014
San Bernardino	616,244	0.0507
San Diego	1,038,012	0.0855
San Francisco	328,665	0.0271
San Joaquin	206,013	0.0170
San Luis Obispo	105,338	0.0087
San Mateo	245,577	0.0202
Santa Barbara	139,101	0.0115
Santa Clara	562,189	0.0463
Santa Cruz	94,393	0.0078
Shasta	69,783	0.0057
Sierra	2,093	0.0002
Siskiyou	21,571	0.0018
Solano	137,241	0.0113
Sonoma	180,592	0.0149
Stanislaus	157,919	0.0130
Sutter	30,385	0.0025
Tehama	23,847	0.0020
Trinity	7,607	0.0006
Tulare	121,910	0.0100
Tuolumne	27,842	0.0023
Ventura	249,543	0.0205
Yolo	65,166	0.0054
Yuba	24,960	0.0021
Total	**12,146,777**	

Statewide Equipment Population Estimates and Quality Assurance

Equipment/fuel type combinations were aggregated across sectors for a final statewide population total, as shown in Table 77. Some minor adjustments were made to the sector level totals presented in Tables 69 thru 72, aggregating certain specialty equipment into "Other" categories, and allocating a small number of equipment categories without a reported fuel type to specific fuel categories, as discussed in Section 3.1.4. Population totals are also provided from the current OFFROAD and NONROAD models for comparison as well. Many of the model values were developed using top-down estimation methods, for example allocating national totals obtained from surveys to the state level. In fact, the lack of bottom-up survey data was a main impetus for this study, and the substantial differences between the study estimates and model values reflect the differences in the methodologies used to obtain them.

Table 77. Estimated Statewide Off-road Equipment Population – All Sectors

Equipment Type	Fuel Type	Study Estimate	NONROAD	OFFROAD
Aerial Lifts	Comp. Gas	128	2,065	834
Aerial Lifts	Diesel	230	6,614	5,859
Aerial Lifts	Gasoline	66	3,854	2,514
Agricultural Mowers	Diesel	778	8	66
Agricultural Mowers	Gasoline	5,663	230	1,996
Agricultural Tractors	Comp. Gas	300	-	-
Agricultural Tractors	Diesel	101,675	29,618	155,198
Agricultural Tractors	Gasoline	98,105	73	531
Air Compressors	Comp. Gas	654	1,054	-
Air Compressors	Diesel	3,832	11,411	7,561
Air Compressors	Gasoline	8,620	16,306	11,667
All Terrain Vehicles	Diesel	9,564	-	-
All Terrain Vehicles	Gasoline	70,486	122,770	316,166
Balers	Diesel	2,252	153	1,410
Balers	Gasoline	23	503	2,577
Bore/Drill Rigs	Diesel	1,020	2,893	666
Bore/Drill Rigs	Gasoline	306	11,165	339
Cement and Mortar Mixers	Diesel	128	1,504	557
Cement and Mortar Mixers	Gasoline	1,733	26,500	28,795
Chainsaws	Gasoline	439,292	162,048	765,463
Chippers/Stump Grinders	Diesel	409	8,421	274
Chippers/Stump Grinders	Gasoline	26,671	4,681	2,080
Combines	Comp. Gas	83	-	-
Combines	Diesel	1,825	3,784	2,626
Combines	Gasoline	189	-	-
Concrete/Industrial Saws	Gasoline	510	11,374	4,182
Cranes	Diesel	373	1,565	780
Cranes	Gasoline	23	113	77
Crawler Tractors	Diesel	745	5,005	10,645
Crawler Tractors	Gasoline	194	-	-
Excavators	Diesel	1,772	8,612	12,511
Excavators	Gasoline	41	-	-
Industrial forklifts	Comp. Gas	54,192	44,590	25,142
Industrial forklifts	Diesel	8,962	4,585	3,163
Industrial forklifts	Gas/Propane	429	-	-
Industrial forklifts	Gasoline	11,772	2,347	13,721
Front/Riding Mowers	Diesel	1,279	-	-
Front/Riding Mowers	Gasoline	163,936	27,753	351,546
Generator Sets	Comp. Gas	500	16,957	353
Generator Sets	Diesel	1,863	72,333	20,660
Generator Sets	Gasoline	44,317	260,174	274,903
Golf Carts	Gasoline	18,896	10,213	31,874
Graders	Diesel	2,328	1,202	4,139
Hydro Power Units	Gasoline	102	2,919	961
Irrigation Sets	Diesel	428	595	-

Equipment Type	Fuel Type	Study Estimate	NONROAD	OFFROAD
Lawn Mowers	Gasoline	1,455,276	138,192	4,309,960
Leaf Blowers/Vacuums	Gasoline	192,665	175,079	1,262,105
Materials Handling (Other)	Diesel	8	519	94
Minibikes	Gasoline	8,731	-	8,034
Off-Road Motorcycles Active	Gasoline	123,809	98,730	325,183
Other Agricultural Equipment	Diesel	2,520	442	3,205
Other Agricultural Equipment	Gasoline	606	597	762
Other Construction Equipment	Diesel	1,319	402	811
Other Construction Equipment	Gasoline	816	70	70
Other General Industrial Equipment	Gasoline	2,387	9,468	1,770
Other Lawn and Garden Equipment	Gasoline	10,003	184,126	356,190
Pavers	Diesel	107	1,850	2,554
Paving Equipment	Gasoline	128	13,040	20,716
Personal Water Craft	Gasoline	25,837	82,768	197,987
Plate Compactor	Diesel	107	2,324	322
Pressure Washers	Gasoline	30,699	115,388	27,120
Pumps	Diesel	1,456	13,581	11,272
Pumps	Gasoline	1,868	126,560	62,155
Rollers	Diesel	1,662	7,765	7,569
Rollers	Gasoline	413	1,078	2,359
Rubber Tired Loaders	Diesel	6,624	7,140	11,849
Rubber Tired Loaders	Gasoline	366	169	191
Scrapers	Diesel	222	54	396
Shredders	Gasoline	20,972	58,827	248,877
Signal Boards	Diesel	102	6,801	3,200
Skid Steer Loaders	Diesel	4,576	56,267	28,460
Skidders	Diesel	165	-	707
Snowblowers	Gasoline	7,535	112,965	72,895
Snowmobiles	Gasoline	1,733	14,179	17,630
Specialty Vehicles Carts	Gasoline	16,910	54,779	68,501
Sprayers	Diesel	1,834	720	1,332
Sprayers	Dual Gas/ Electric	306	-	-
Sprayers	Gasoline	6,326	5,365	9,798
Swathers	Diesel	1,122	1,673	7,681
Swathers	Gasoline	41	314	3,088
Sweepers/Scrubbers	Gasoline	242	2,596	8
Tampers/Rammers	Gasoline	242	16,961	3,177
Tillers	Gasoline	88,445	20,161	261,198
Tractors/Loaders/Backhoes	Comp. Gas	214	19	-
Tractors/Loaders/Backhoes	Diesel	18,722	36,091	26,187
Tractors/Loaders/Backhoes	Gasoline	2,417	878	88
Transport Refrigeration Units	Gasoline	52,157	137	5,090
Trenchers	Diesel	23	5,860	7,682
Trenchers	Gasoline	642	3,355	2,592
Trimmers/Edgers/Brush Cutters	Gasoline	560,275	157,114	3,066,112
Vessels w/Outboard Engines	Gasoline	32,246	435,530	525,290

Equipment Type	Fuel Type	Study Estimate	NONROAD	OFFROAD
Welders	Comp. Gas	214	1,159	-
Welders	Diesel	110	24,842	11,576
Welders	Gasoline	1,060	23,386	36,064
Wood Splitters	Gasoline	364	-	206,535

Table 78 lists the equipment types assigned to the various "Other" categories indicated above. None of these equipment types were explicitly included in the standard OFFROAD model equipment list. Assignments to Agricultural, Construction, General Industrial, and Lawn and Garden categories were based on expert judgment, utilizing make and model information (where available) and application type descriptions. The Agricultural sector had by far the greatest number of specialty equipment assigned in this manner, as shown below.

Table 78. "Other" Equipment Category Assignments

Equipment Category Assignment	Reported Equipment Types
Other Agricultural Equipment	Sweepers, Balancers, Bale Hauler, Unspecified[17] Diesel Motor, Feed Feeder, Pruning Towers, Shakers, Splice, Spreaders, Unspecified "Caterpillar", Unspecified "Yard Truck"
Other Construction Equipment	"Champ", Pipe Threader, Unspecified "Off-road truck", Unspecified "Vacuum"
Other General Industrial Equipment	Car Lift, Alignment Rack, Vacuum Pot Holer
Other Lawn and Garden Equipment	"Dirt Remover", Thatcher, "Yard Burn"

A limited number of equipment/fuel type combinations could not be matched to existing OFFROAD categories, but were deemed inappropriate for assignment to the "other" categories. Several cases involved existing equipment categories without a corresponding fuel type. Specifically, the following equipment/fuel type combinations were reported and confirmed by survey respondents, although they are not currently included in the OFFROAD model population listing. With the exception of diesel powered ATVs, each of these combinations were reported by no more than two respondents. Accordingly, statewide populations of these equipment types are expected to be very low. (A detailed statistical analysis describing the relationship between survey response rates and resulting population uncertainty is provided in Section 4.2).

- Compressed gas agricultural tractors;
- Compressed gas air compressors;
- Diesel ATVs;
- Gasoline crawler tractors;
- Gasoline excavators;
- Dual fuel gasoline/LPG industrial forklifts;
- Diesel irrigation sets;
- Diesel front/riding mowers;
- Dual gasoline/electric sprayers;

[17] Attempts were made to obtain clarification on "unspecified" equipment descriptions without success.

- Compressed gas tractor/loader/backhoes; and,
- Compressed gas welders

In addition, certain specialty equipment categories found in the OFFROAD model were not reported by survey respondents. Of those OFFROAD equipment categories with more than 1,000 units estimated at the state level, the following were not identified during the survey (with OFFROAD population estimates for all fuel types provided in parentheses):

- Airport ground support equipment (GSE - various types – 4,491);
- Commercial turf equipment (25,184);
- Dumpers/tenders (1,961);
- Fellers/bunchers (1,322)
- Lawn and garden tractors (281,802);
- Off-highway tractors (1,224);
- Rough terrain forklifts (6,265);
- Sailboat auxiliary engines (inboard and outboard – 19,988); and,
- Surfacing equipment (5,552).

GSE and commercial turf equipment are likely absent from the survey data set since airports and commercial lawn and garden companies were not explicitly targeted for survey. In addition, the relative scarcity of dumpers/tenders and off-highway tractors may explain their absence from the final survey findings as well. Also, it is quite possible that some fraction of residential lawn and garden tractors were misclassified by respondents and included under the Front/Riding mower category. However, specific survey strata were designed to capture logging, construction, and recreational equipment, and the reason for the absence of the remaining categories (fellers/bunchers, lawn tractors, rough terrain forklifts, sailboat auxiliary engines, and surfacing equipment) is unknown.

As shown in Table 77, statewide population estimates are provided for equipment less than 175 hp, from both the OFFROAD model and EPA's NONROAD model. While not definitive, since neither data source has been independently validated, these alternative data sources provide an independent point of reference for assessing the validity of the study's population estimates. A qualitative comparison among the three sets of numbers yields the following observations. (A quantitative uncertainty assessment follows in Section 4.2).

1. *Most agricultural equipment estimates are roughly consistent with, or somewhat higher than, OFFROAD and NONROAD estimates.* This holds true for all but the gasoline agricultural mower category, which is substantially higher than the OFFROAD value (5,663 compared to 1,996), and the diesel swather category, which at 1,122 is substantially lower than the OFFROAD estimate of 7,681 (but closer to the NONROAD estimate of 1,673).

   As an additional check, selected agricultural equipment types were compared with population estimates obtained from the 2002 Agricultural Census, as shown in Table 79. The projections for agricultural tractors and combines are quite similar for both sources, although baler totals for this study are substantially lower than those from the Agricultural Census. (Note that Agricultural Census equipment

data is not broken out by fuel type, so estimates have been aggregated accordingly.)

Table 79. Comparison of Selected Agricultural Equipment Estimates with Agricultural Census Values

Equipment Category	Population Estimate	Ag Census Estimate
Agricultural Tractors	200,081	184,981
Balers	2,275	4,836
Combines	2,097	2,540

However, while *total* agricultural tractor estimates from the study are comparable to Agricultural Census Estimates, and slightly higher than the OFFROAD estimates (~200,000 vs. 155,000), the tractor fuel type distribution is significantly different than expected, with a much larger fraction of tractors being powered by gasoline than is assumed in the OFFROAD model. As seen in Table 71, the vast majority of gasoline agricultural tractors were actually attributable to the Residential rather than the Agricultural sector. While there were only 13 (unweighted) gasoline agricultural tractors reported in the Residential sector survey, the very large surrogate multipliers associated with this sector result in correspondingly large statewide population estimates.

Further investigation using web searches definitively confirmed a gasoline engine type and the agricultural tractor category for nine of the 13 units reported for this sector.[18] In addition, none of the units were reported to be newer than the 1961 model year. Also, 10 of the 13 units were reported to be used primarily for "Personal or Residential" or "Recreational" purposes, with an unweighted average utilization of 39 hours per year. From this limited data set it appears these units may be considered "antique" and/or "novelty" equipment with very low activity levels.

Finally, eight of the 13 units reported in this sector were owned by a single respondent. While extensive efforts were made to obtain a representative survey sample in all sectors, this particular respondent may be considered an "outlier," which if true would substantially overestimate the resulting statewide equipment population estimates. (For example, assuming that all Residential sector operators of gasoline agricultural tractors own just a single unit reduces population estimates by over 60%). However, given the stratified random sampling methodology adopted for the survey, such a bias cannot be determined definitively.

2. *The majority of construction equipment category totals are consistently lower than OFFROAD and NONROAD.* This observation holds for both small construction equipment such as concrete saws and tampers/rammers, as well as larger categories such as crawler tractors and excavators. Construction equipment

[18] Data for make and model year were missing for the remaining four units, making independent confirmation of equipment and fuel type not possible.

categories with estimates roughly similar to those in OFFROAD include bore/drill rigs, cranes, graders, plate compactors, loaders, scrapers and tractors/loaders/backhoes.

3. *Industrial forklift population estimates are substantially higher than estimated by OFFROAD.* Aside from generator sets, industrial forklifts are estimated to be the most common type of industrial off-road equipment in use (as per OFFROAD, NONROAD, and the study projections themselves). While population estimates for gasoline powered industrial forklifts were similar between the study values and OFFROAD, the study estimates for diesel and LPG powered units were two to three times the corresponding OFFROAD values. NONROAD estimates for LPG industrial forklifts were substantially closer to the study values, however.

4. *Estimates for many other common industrial and recreational equipment categories were consistently lower than model values.* Study estimates for air compressors were substantially lower than OFFROAD as well as NONROAD estimates, while projections for generator sets, pumps, and welders were dramatically lower – close to an order of magnitude for diesel units and even more for gasoline pumps. Pressure washer estimates were quite similar however. While ATV, golf cart, off-road motorcycle, and minibike estimates were somewhat lower than OFFROAD values (but reasonably close to NONROAD estimates), other recreational equipment estimates appear to be far lower than corresponding model values – approximately an order of magnitude for outboard engines and personal watercraft. This finding may reflect a systematic response bias wherein respondents did not associate watercraft with "off-road" equipment, even though these were explicitly mentioned as example equipment types during Residential sector interviews.

5. *Estimates for transportation refrigeration units (TRUs) are most likely skewed very high.* One survey respondent in the Residual sector reported having 130 gasoline powered TRUs. No other respondent reported a single TRU throughout the rest of the study. Applying the selected surrogates to this one respondent's data results in an estimate more than an order of magnitude above the projected OFFROAD value. Accordingly, we recommend dropping this observation from the data set as unrepresentative of the population of TRUs as a whole.

6. *Residential lawn and garden equipment estimates fall consistently between the corresponding NONROAD and OFFROAD estimates.* In almost all cases, the study population estimates for these equipment types are lower than the corresponding OFFROAD values (typically three to five times lower), and substantially higher than the corresponding NONROAD values (commonly three to five times higher). The largest percentage discrepancy occurs in the wood splitter category, with the study estimates almost two orders of magnitude lower than OFFROAD estimates. The second largest discrepancy with OFFROAD values occurs with the chipper/stump grinder and shredder categories. In this case, however, the study estimate for chippers/grinders is an order of magnitude higher than those for OFFROAD. On the other hand, estimates for shredders are roughly an order of magnitude lower than the corresponding OFFROAD values. Some of

this discrepancy may be due to respondents mistakenly assigning shredders to the chipper category.

4.1.3 Statewide Equipment Activity Profiles

Sector level activity totals and equipment populations were combined across all sectors to determine average annual activity for each equipment/fuel type combination at the state level. Table 80 presents the statewide average hours per year for each equipment category, as well as the corresponding estimates from the OFFROAD and NONROAD models. Note that activity values for lawn and garden equipment were based on residential rather than commercial values, since the vast majority of the surveyed equipment originated in the Residential sector.

Table 80. Average Annual Activity – Estimated Statewide Equipment Population (Hrs/Yr)

Equipment Type	Fuel Type	Study Estimate	NONROAD	OFFROAD
Aerial Lifts	Comp. Gas	30	-	375
Aerial Lifts	Diesel	133	384	399
Aerial Lifts	Gasoline	100	361	375
Agricultural Mowers	Diesel	70	363	363
Agricultural Mowers	Gasoline	540	175	180
Agricultural Tractors	Comp. Gas	1,125	550	-
Agricultural Tractors	Diesel	301	475	475
Agricultural Tractors	Gasoline	54	550	550
Air Compressors	Comp. Gas	216	484	-
Air Compressors	Diesel	556	815	815
Air Compressors	Gasoline	163	484	484
All Terrain Vehicles	Diesel	70	-	-
All Terrain Vehicles	Gasoline	168	1,608	1,323 (mi/yr)
Balers	Diesel	361	95	95
Balers	Gasoline	300	68	68
Bore/Drill Rigs	Diesel	1,600	466	811
Bore/Drill Rigs	Gasoline	150	107	107
Cement and Mortar Mixers	Diesel	1,560	275	300
Cement and Mortar Mixers	Gasoline	128	84	92
Chainsaws	Gasoline	14	13	5
Chippers/Stump Grinders	Diesel	30	465	465
Chippers/Stump Grinders	Gasoline	12	488	17
Combines	Comp. Gas	100	-	-
Combines	Diesel	463	150	150
Combines	Gasoline	93	-	-
Concrete/Industrial Saws	Gasoline	58	610	310
Cranes	Diesel	330	936	1,252
Cranes	Gasoline	15	415	415
Crawler Tractors	Diesel	493	936	1,013
Crawler Tractors	Gasoline	96	700	-
Excavators	Diesel	298	1,092	1,396
Excavators	Gasoline	70	378	-

Equipment Type	Fuel Type	Study Estimate	NONROAD	OFFROAD
Industrial forklifts	Comp. Gas	975	1,800	1,800
Industrial forklifts	Diesel	487	1,700	1,800
Industrial forklifts	Dual Fuel Gas/Propane	12	-	-
Industrial forklifts	Gasoline	157	1,800	1,800
Front Mowers	Diesel	109	480	-
Front Mowers	Gasoline	103	86	28
Generator Sets	Comp. Gas	17	115	115
Generator Sets	Diesel	326	338	338
Generator Sets	Gasoline	102	115	134
Golf Carts	Gasoline	1,000	1,080	1,080
Graders	Diesel	109	962	929
Hydro Power Units	Gasoline	100	450	464
Irrigation Sets	Diesel	1,400	749	-
Lawn Mowers	Gasoline	52	25	16
Leaf Blowers/Vacuums	Gasoline	69	10	5
Minibikes	Gasoline	20	-	135
Off-Road Motorcycles	Gasoline	74 / 30^	1,600	-
Other Agricultural Equipment	Diesel	469	381	381
Other Agricultural Equipment	Gasoline	179	124	124
Other Construction Equipment	Diesel	726	606	690
Other Construction Equipment	Gasoline	1,925	371	371
Other General Industrial Equipment	Gasoline	17	713	713
Other Lawn and Garden Equipment	Gasoline	10	61	4
Pavers	Diesel	100	821	821
Paving Equipment	Gasoline	20	175	175
Personal Water Craft	Gasoline	12	77	41
Pressure Washers	Gasoline	61	115	90
Pumps	Diesel	285	403	403
Pumps	Gasoline	104	221	174
Riding lawn mower(s)	Gasoline	20	36	28
Rollers	Diesel	270	760	695
Rollers	Gasoline	170	621	621
Rubber Tired Loaders	Diesel	414	761	957
Rubber Tired Loaders	Gasoline	216	512	512
Scrapers	Diesel	852	914	1,092
Shredders	Gasoline	18	50	1
Signal Boards	Diesel	60	535	535
Skid Steer Loaders	Diesel	574	818	834
Skidders	Diesel	817	1,276	1,442
Snowblowers	Gasoline	10	8	2
Snowmobiles	Gasoline	2	57	57
Specialty Vehicles Carts	Gasoline	100	65	65
Sprayers	Diesel	386	90	90
Sprayers	Dual Gas/ Electric	1,000	-	-
Sprayers	Gasoline	170	80	80

Equipment Type	Fuel Type	Study Estimate	NONROAD	OFFROAD
Swathers	Diesel	133	110	110
Swathers	Gasoline	35	95	95
Tampers/Rammers	Gasoline	10	160	182
Tillers	Gasoline	83	43	18
Tractors/Loaders/Backhoes	Diesel	1,085	1,135	942
Tractors/Loaders/Backhoes	Gasoline	1,378	870	870
Transport Refrigeration Units	Gasoline	2,300	605	750
Trenchers	Diesel	250	593	618
Trenchers	Gasoline	4	402	402
Trimmers/Edgers/Brush Cutters	Gasoline	46	9	22
Vessels w/Outboard Engines	Gasoline	22	35	48
Welders	Diesel	107	643	643
Welders	Gasoline	66	408	208
Wood Splitters	Gasoline	8	76	1

^ 30 hours per year when adjusted for likely outlier (see Section 4.3 for discussion)

Unlike the population analysis presented in section 4.1.2, activity values in the OFFROAD and NONROAD models tend to be quite similar. A qualitative comparison across the study, OFFROAD and NONROAD model estimates yields the following observations.

1. No systematic pattern is evident among agricultural equipment, with activity estimates ranging well above and below OFFROAD estimates.
2. In general, construction equipment estimates are systematically lower than corresponding model estimates. Activity estimates for construction equipment clearly follow this pattern, with the following exceptions: tractors/loaders/backhoes have similar activity estimates, as do skid steer loaders to a lesser extent; and cement and mortar mixers, as well as bore/drill rigs have substantially higher activity estimates than OFFROAD.
3. Industrial equipment activity values are similar to, or somewhat lower than, corresponding model estimates. While aerial lifts, air compressors, and welders have distinctly lower activity values than OFFROAD, values for generator sets, pressure washers and pumps are reasonably similar. In addition, activity estimates for industrial forklifts of all fuel types are lower than corresponding OFFROAD values. However, the estimates for LPG industrial forklifts compare quite favorably with an independent estimate of industrial forklift activity in the Dallas/Fort Worth area developed for the Texas Commission on Environmental Quality (TCEQ) - 975 hrs/yr vs. 1,124 hrs/yr for the TCEQ study.(13)
4. Residential lawn and garden activity estimates are systematically higher than OFFROAD model estimates. With the exception of chippers and stump grinders which have lower activity values, these equipment types all have substantially higher activity estimates than the corresponding OFFROAD values.
5. Recreational equipment estimates are systematically lower than corresponding OFFROAD estimates. With the exception of golf carts, which have similar

activity values to those in OFFROAD, these equipment types all have substantially lower hour per year estimates than OFFROAD.

4.1.4 Statewide Equipment HP Profiles

Sector level hp values and equipment populations were combined across all sectors to determine average hp for each equipment/fuel type combination at the state level. Table 81 presents the statewide average hp estimates for each equipment category, as well as the associated estimates from the OFFROAD and NONROAD models less than 175 hp. Table 82 presents the corresponding distributions by hp bin for the projected statewide equipment population.

Table 81. Weighted Average HP – Estimated Statewide Equipment Population

Equipment Type	Fuel Type	Study Estimate	NONROAD	OFFROAD
Aerial Lifts	Comp. Gas	45	51.5	18.9
Aerial Lifts	Diesel	49	48.8	43.1
Aerial Lifts	Gasoline	37	36.5	40.8
Agricultural Mowers	Diesel	33	76.0	65.0
Agricultural Mowers	Gasoline	22	11.3	12.5
Agricultural Tractors	Comp. Gas	56	-	-
Agricultural Tractors	Diesel	63	74.2	67.4
Agricultural Tractors	Gasoline	35	57.0	87.2
Air Compressors	Comp. Gas	37	62.8	-
Air Compressors	Diesel	33	70.8	73.9
Air Compressors	Gasoline	17	2.2	15.4
All Terrain Vehicles	Diesel	19	-	-
All Terrain Vehicles	Gasoline	48	-	20.1
Balers	Diesel	72	80.8	75.0
Balers	Gasoline	62	43.9	44.8
Bore/Drill Rigs	Diesel	127	82.0	77.9
Bore/Drill Rigs	Gasoline	82	3.6	47.0
Cement and Mortar Mixers	Diesel	10	22.1	10.3
Cement and Mortar Mixers	Gasoline	6	7.5	6.9
Chainsaws	Gasoline	5	2.1	1.7
Chippers/Stump Grinders	Diesel	39	86.8	84.8
Chippers/Stump Grinders	Gasoline	8	28.5	17.0
Combines	Diesel	125	136.8	128.3
Combines	Gasoline	50	124.1	124.8
Concrete/Industrial Saws	Gasoline	6	4.1	11.0
Cranes	Diesel	150	128.2	117.6
Crawler Tractors	Diesel	147	120.6	99.4
Crawler Tractors	Gasoline	7	-	-
Excavators	Diesel	85	107.2	126.7
Excavators	Gasoline	25	-	-
Industrial forklifts	Comp. Gas	61	70.9	65.8
Industrial forklifts	Diesel	70	82.6	97.5
Industrial forklifts	Gasoline	74	73.2	65.8
Front/Riding Mowers	Diesel	22	-	-

Equipment Type	Fuel Type	Study Estimate	NONROAD	OFFROAD
Front/Riding Mowers	Gasoline	15	13.5	14.8
Generator Sets	Comp. Gas	6	56.4	111.6
Generator Sets	Diesel	46	39.6	44.5
Generator Sets	Gasoline	12	1.6	12.6
Golf Carts	Gasoline	23	9.2	9.0
Graders	Diesel	88	134.8	147.1
Hydro Power Units	Gasoline	18	1.7	9.6
Irrigation Sets	Diesel	143	89.8	-
Lawn Mowers	Gasoline	5	4.1	4.0
Leaf Blowers/Vacuums	Gasoline	7	1.4	1.0
Materials Handling (Other)	Diesel	97	95.9	118.7
Minibikes	Gasoline	19	-	4.0
Off-Road Motorcycles	Gasoline	44	-	33.6
Other Agricultural Equipment	Comp. Gas	75	154.0	-
Other Agricultural Equipment	Diesel	69	98.6	61.3
Other Agricultural Equipment	Gasoline	61	35.6	39.5
Other Construction Equipment	Diesel	37	108.7	61.6
Other Construction Equipment	Gasoline	21	122.6	126.0
Other General Industrial Equipment	Gasoline	97	7.4	17.9
Other Lawn and Garden Equipment	Gasoline	14	5.4	5.2
Pavers	Diesel	74	89.4	89.5
Paving Equipment	Gasoline	6	1.8	8.4
Personal Water Craft	Gasoline	139	107.1	61.5
Pressure Washers	Gasoline	7	7.5	7.0
Pumps	Diesel	81	45.3	46.1
Pumps	Gasoline	8	1.7	8.0
Riding lawn mower(s)	Gasoline	12	10.7	10.7
Rollers	Diesel	49	73.1	86.7
Rollers	Gasoline	5	15.3	14.0
Rubber Tired Loaders	Diesel	82	112.2	110.6
Rubber Tired Loaders	Gasoline	24	71.1	67.8
Scrapers	Diesel	133	159.9	158.1
Shredders	Gasoline	6	4.2	4.6
Signal Boards	Diesel	62	23.7	18.3
Skid Steer Loaders	Diesel	62	54.8	43.9
Skidders	Diesel	147	130.5	132.1
Snowblowers	Gasoline	8	8.9	6.2
Snowmobiles	Gasoline	40	49.3	52.9
Specialty Vehicle Carts	Gasoline	77	20.1	8.6
Sprayers	Diesel	76	102.5	84.1
Sprayers	Gasoline	26	1.7	15.0
Swathers	Diesel	112	89.2	78.6
Sweepers/Scrubbers	Gasoline	5	1.3	35.7
Tampers/Rammers	Gasoline	4	3.8	4.2
Tillers	Gasoline	6	7.5	5.6
Tractors/Loaders/Backhoes	Diesel	59	93.3	77.1
Tractors/Loaders/Backhoes	Gasoline	19	19.6	63.0

Equipment Type	Fuel Type	Study Estimate	NONROAD	OFFROAD
Transport Refrigeration Units	Gasoline	50	17.7	12.0
Trenchers	Diesel	60	62.3	59.6
Trenchers	Gasoline	9	12.2	20.5
Trimmers/Edgers/Brush Cutters	Comp. Gas	5	-	-
Trimmers/Edgers/Brush Cutters	Gasoline	5	3.3	0.9
Vessels w/Outboard Engines	Diesel	8	32.3	-
Vessels w/Outboard Engines	Gasoline	36	60.2	29.5
Welders	Comp. Gas	14	66.1	-
Welders	Diesel	94	44.1	45.1
Welders	Gasoline	14	17.3	21.2
Wood Splitters	Gasoline	9	-	5.0

Table 82. Weighted HP Distribution – Estimated Statewide Equipment Population

Equipment Type	Fuel Type	0 - 11	11 - 24	25 - 49	50 - 74	75 - 119	120 - 174
Aerial Lifts	Comp. Gas	0%	0%	100%	0%	0%	0%
Aerial Lifts	Diesel	38%	0%	0%	0%	62%	0%
Aerial Lifts	Gasoline	0%	0%	100%	0%	0%	0%
Agricultural Mowers	Diesel	9%	51%	0%	40%	0%	0%
Agricultural Mowers	Gasoline	3%	27%	70%	0%	0%	0%
Agricultural Tractors	Comp. Gas	0%	0%	52%	23%	25%	0%
Agricultural Tractors	Diesel	0%	10%	25%	33%	24%	8%
Agricultural Tractors	Gasoline	7%	42%	42%	2%	0%	7%
Air Compressors	Comp. Gas	0%	0%	100%	0%	0%	0%
Air Compressors	Diesel	13%	19%	56%	6%	6%	0%
Air Compressors	Gasoline	67%	10%	11%	9%	3%	0%
All Terrain Vehicles	Diesel	0%	91%	6%	0%	2%	0%
All Terrain Vehicles	Gasoline	15%	32%	12%	16%	15%	10%
Balers	Diesel	0%	0%	0%	79%	6%	15%
Balers	Gasoline	0%	0%	0%	100%	0%	0%
Bore/Drill Rigs	Diesel	0%	0%	0%	0%	40%	60%
Bore/Drill Rigs	Gasoline	0%	50%	0%	0%	0%	50%
Cement and Mortar Mixers	Diesel	100%	0%	0%	0%	0%	0%
Cement and Mortar Mixers	Gasoline	100%	0%	0%	0%	0%	0%
Chainsaws	Gasoline	100%	0%	0%	0%	0%	0%
Chippers/Stump Grinders	Diesel	0%	0%	98%	0%	0%	2%
Chippers/Stump Grinders	Gasoline	70%	30%	0%	0%	0%	0%
Combines	Diesel	4%	5%	0%	40%	19%	32%
Combines	Gasoline	0%	0%	0%	100%	0%	0%
Concrete/Industrial Saws	Gasoline	80%	20%	0%	0%	0%	0%
Cranes	Diesel	0%	0%	0%	0%	0%	100%
Crawler Tractors	Diesel	0%	0%	0%	0%	21%	79%
Crawler Tractors	Gasoline	96%	0%	4%	0%	0%	0%
Excavators	Diesel	20%	0%	15%	13%	19%	33%
Excavators	Gasoline	0%	0%	100%	0%	0%	0%
Industrial forklifts	Comp. Gas	5%	9%	22%	42%	9%	14%
Industrial forklifts	Diesel	4%	4%	37%	28%	9%	19%

Equipment Type	Fuel Type	0 - 11	11 - 24	25 - 49	50 - 74	75 - 119	120 - 174
Industrial forklifts	Gasoline	0%	9%	13%	33%	33%	11%
Front/Riding Mowers	Diesel	0%	58%	42%	0%	0%	0%
Front/Riding Mowers	Gasoline	26%	61%	13%	0%	0%	0%
Generator Sets	Comp. Gas	100%	0%	0%	0%	0%	0%
Generator Sets	Diesel	36%	17%	7%	7%	33%	0%
Generator Sets	Gasoline	56%	40%	1%	3%	1%	0%
Golf Carts	Gasoline	0%	44%	56%	0%	0%	0%
Graders	Diesel	0%	0%	0%	4%	79%	17%
Hydro Power Units	Gasoline	0%	100%	0%	0%	0%	0%
Irrigation Sets	Diesel	0%	0%	0%	0%	50%	50%
Lawn Mowers	Gasoline	100%	0%	0%	0%	0%	0%
Leaf Blowers/Vacuums	Gasoline	88%	8%	3%	0%	0%	0%
Materials Handling (Other)	Diesel	0%	0%	0%	0%	100%	0%
Minibikes	Gasoline	0%	95%	0%	0%	5%	0%
Off-Road Motorcycles	Gasoline	8%	8%	49%	28%	0%	6%
Other Ag. Equipment	Comp. Gas	0%	0%	0%	0%	100%	0%
Other Ag. Equipment	Diesel	2%	0%	48%	9%	25%	16%
Other Ag. Equipment	Gasoline	39%	13%	12%	0%	0%	37%
Other Construction Equip.	Diesel	0%	0%	100%	0%	0%	0%
Other Construction Equip.	Gasoline	25%	63%	0%	0%	13%	0%
Other General Industrial Equipment	Gasoline	0%	0%	0%	0%	100%	0%
Other Lawn and Garden Equipment	Gasoline	43%	57%	0%	0%	0%	0%
Pavers	Diesel	0%	0%	0%	100%	0%	0%
Paving Equipment	Gasoline	100%	0%	0%	0%	0%	0%
Personal Water Craft	Gasoline	0%	0%	0%	0%	2%	98%
Pressure Washers	Gasoline	81%	19%	0%	0%	0%	0%
Pumps	Diesel	0%	10%	7%	38%	18%	28%
Pumps	Gasoline	76%	24%	0%	0%	0%	0%
Riding lawn mowers	Gasoline	0%	100%	0%	0%	0%	0%
Rollers	Diesel	0%	13%	65%	7%	7%	7%
Rollers	Gasoline	100%	0%	0%	0%	0%	0%
Rubber Tired Loaders	Diesel	0%	0%	12%	26%	49%	12%
Rubber Tired Loaders	Gasoline	0%	11%	89%	0%	0%	0%
Scrapers	Diesel	0%	0%	0%	0%	6%	94%
Shredders	Gasoline	100%	0%	0%	0%	0%	0%
Signal Boards	Diesel	0%	0%	0%	100%	0%	0%
Skid Steer Loaders	Diesel	0%	0%	28%	34%	38%	0%
Skidders	Diesel	0%	0%	0%	0%	0%	100%
Snowblowers	Gasoline	100%	0%	0%	0%	0%	0%
Snowmobiles	Gasoline	0%	0%	100%	0%	0%	0%
Specialty Vehicle Carts	Gasoline	49%	0%	1%	0%	0%	49%
Sprayers	Diesel	0%	5%	15%	5%	64%	10%
Sprayers	Gasoline	41%	41%	5%	0%	9%	4%
Swathers	Diesel	0%	0%	0%	0%	57%	43%
Sweepers/Scrubbers	Gasoline	100%	0%	0%	0%	0%	0%

Equipment Type	Fuel Type	0 - 11	11 - 24	25 - 49	50 - 74	75 - 119	120 - 174
Tampers/Rammers	Gasoline	100%	0%	0%	0%	0%	0%
Tillers	Gasoline	100%	0%	0%	0%	0%	0%
Tractors/Loaders/Backhoes	Diesel	0%	8%	42%	14%	36%	1%
Tractors/Loaders/Backhoes	Gasoline	0%	81%	4%	15%	0%	0%
Transport Refrigeration Units	Gasoline	0%	0%	0%	100%	0%	0%
Trenchers	Diesel	0%	0%	0%	100%	0%	0%
Trenchers	Gasoline	62%	38%	0%	0%	0%	0%
Trimmers/Edgers/Brush Cutters	Comp. Gas	100%	0%	0%	0%	0%	0%
Trimmers/Edgers/Brush Cutters	Gasoline	93%	7%	0%	0%	0%	0%
Vessels w/Outboard Engines	Diesel	100%	0%	0%	0%	0%	0%
Vessels w/Outboard Engines	Gasoline	22%	0%	57%	21%	0%	0%
Welders	Comp. Gas	0%	100%	0%	0%	0%	0%
Welders	Diesel	0%	7%	0%	0%	93%	0%
Welders	Gasoline	41%	49%	10%	0%	1%	0%
Wood Splitters	Gasoline	100%	0%	0%	0%	0%	0%

Several observations can be made based on the Table 81 data. First, in qualitative terms, there is greater consistency between the study average hp values and those in OFFROAD and NONROAD, compared with the population and activity values. Second, there is broad general agreement among several key equipment categories, including diesel powered agricultural tractors, diesel and gasoline generator sets, and compressed gas industrial forklifts. Third, construction equipment hp averages appear to be systematically lower than the corresponding OFFROAD model estimates, with the exception of bore/drill rigs and signal boards, which have substantially higher hp than the model values. Finally, residential lawn and garden equipment and recreational equipment appear to have substantially higher hp averages than OFFROAD, often by 100 percent or more. In absolute terms the differences for lawn and garden equipment are relatively small though, corresponding to a few hp in most cases.

4.2 Uncertainty Analysis and Confidence Intervals

An analysis was conducted to determine the error bounds associated with the population, average hours per year, and average hp estimates developed for the statewide equipment profiles presented in Section 4.1. The error bounds take into account both the number of observations for a particular parameter, as well as the variability of the response itself. For example, an average hp value based on three responses covering a wide range will be much more uncertain than an average based on 50 responses covering a narrow range. The resulting error estimates can be used by ARB to determine which equipment profile parameters are deemed acceptable for inclusion in the OFFROAD model, and which parameters should be based on alternative data sources.

The following analyses assume that the estimates of the mean for a given distribution (e.g., average equipment ownership per respondent, average activity, and average hp) are normally

distributed. Accordingly, the confidence interval associated with any particular mean value can be calculated as a function of the sample size and the standard deviation of the distribution, as shown in Equation 1.

Equation 1. $CI_p = t_{n-1} * \sigma / \sqrt{n}$

Where: *CI = Confidence Interval*
p = Selected probability level
t_{n-1} *= t-value of student's t-test distribution with n-1 degrees of freedom*
σ *= standard deviation of the distribution*
n = number of observations in distribution

For this analysis error bounds are reported at the 95% level of confidence (p = 0.05).

4.2.1 Activity Estimates

Confidence intervals were calculated for annual activity estimates for each equipment/fuel type combination, and are presented as a percent of the statewide average in Table 83. Equipment categories for which confidence intervals could not be calculated (having only one observation in the survey data set) are not presented.

Table 83. 95% Confidence Intervals - Estimated Statewide Activity Estimates

Equipment Type	Fuel Type	# Survey Observations*	Weighted Average (Hrs/Yr)	95% Interval (% of Average)
Aerial Lifts	Diesel	2	133	545%
Agricultural Mowers	Diesel	4	70	155%
Agricultural Mowers	Gasoline	17	540	38%
Agricultural Tractors	Compressed Gas	4	1,125	214%
Agricultural Tractors	Diesel	700	301	8%
Agricultural Tractors	Gasoline	72	54	34%
Air Compressors	Compressed Gas	3	216	215%
Air Compressors	Diesel	24	556	59%
Air Compressors	Gasoline	53	163	23%
All Terrain Vehicles	Diesel	6	70	77%
All Terrain Vehicles	Gasoline	92	168	24%
Balers	Diesel	17	361	50%
Bore/Drill Rigs	Diesel	10	1,600	19%
Bore/Drill Rigs	Gasoline	3	150	204%
Cement and Mortar Mixers	Gasoline	4	128	175%
Chainsaws	Gasoline	94	14	38%
Chippers/Stump Grinders	Diesel	2	30	267%
Combines	Compressed Gas	2	100	0%
Combines	Diesel	20	463	36%
Combines	Gasoline	4	93	273%
Concrete/Industrial Saws	Gasoline	2	58	1,093%
Cranes	Diesel	6	330	107%

Equipment Type	Fuel Type	# Survey Observations*	Weighted Average (Hrs/Yr)	95% Interval (% of Average)
Crawler Tractors	Diesel	9	493	62%
Crawler Tractors	Gasoline	2	96	1,040%
Excavators	Diesel	15	298	53%
Industrial forklifts	Compressed Gas	139	975	22%
Industrial forklifts	Diesel	30	487	54%
Industrial forklifts	Gasoline	27	157	55%
Front/Riding Mowers	Diesel	2	109	908%
Front/Riding Mowers	Gasoline	39	103	59%
Generator Sets	Compressed Gas	2	17	1,050%
Generator Sets	Diesel	10	326	74%
Generator Sets	Gasoline	95	102	35%
Golf Carts	Gasoline	4	1,000	154%
Graders	Diesel	9	109	139%
Irrigation Sets	Diesel	2	1,400	545%
Lawn Mowers	Gasoline	205	52	39%
Leaf Blowers/Vacuums	Gasoline	32	69	104%
Off-Road Motorcycles	Gasoline	17	74	116%
Personal Water Craft	Gasoline	5	12	56%
Pressure Washers	Gasoline	18	61	89%
Pumps	Diesel	8	285	53%
Pumps	Gasoline	14	104	57%
Rollers	Diesel	8	270	99%
Rollers	Gasoline	4	170	81%
Rubber Tired Loaders	Diesel	41	414	35%
Rubber Tired Loaders	Gasoline	4	216	132%
Scrapers	Diesel	3	852	134%
Shredders	Gasoline	4	18	168%
Skid Steer Loaders	Diesel	23	574	53%
Skidders	Diesel	5	817	62%
Snowblowers	Gasoline	5	10	67%
Snowmobiles	Gasoline	4	2	80%
Sprayers	Diesel	12	386	56%
Sprayers	Gasoline	38	170	40%
Swathers	Diesel	5	133	121%
Tillers	Gasoline	20	83	66%
Tractors/Loaders/Backhoes	Diesel	104	1,085	17%
Tractors/Loaders/Backhoes	Gasoline	7	1,378	82%
Transport Refrigeration Units	Gasoline	130	2,300	0%
Trenchers	Gasoline	2	4	1,075%
Trimmers/Edgers/Brush Cutters	Compressed Gas	2	46	666%
Trimmers/Edgers/Brush Cutters	Gasoline	103	22	37%
Vessels w/Outboard Engines	Gasoline	7	107	159%
Welders	Diesel	2	66	424%
Welders	Gasoline	8	8	108%

* unweighted counts of records with activity data – all survey sectors

Several observations can be made based on the above table.

1. *Equipment categories with confidence intervals equal to 0% of the mean activity level are not likely representative of the actual fleet.* 0% intervals were found for compressed gas combines and gasoline TRUs – in other words all units within these equipment types were reported to have the same annual activity levels. In both cases the units were operated by a single respondent. For this reason extrapolations to the remainder of the fleet are deemed unreliable.

2. *95% confidence intervals are relatively large, even for equipment categories with substantial numbers of observations.* In general, activity distributions had large variances resulting in corresponding large confidence intervals. For example, even though activity data were obtained for 72 gasoline agricultural tractors, the resulting uncertainty is still ± 34%.

3. *Of the equipment categories with non-zero confidence intervals, 16 had intervals less than or equal to 50% of the mean value.* These equipment types tended to be those with the greatest number of observations, such as diesel agricultural tractors, compressed gas industrial forklifts, ATVs, and lawn mowers. Agricultural, lawn and garden, and larger construction equipment were most common in this group.

4. *Many equipment categories with a limited number of observations yielded confidence intervals greater than 100% of the mean value.* Twenty seven of the 66 categories in the table had intervals above 100%. Of these only two had more than 10 observations in the survey data set (off-road motorcycles and leaf blowers/vacuums). The actual lower bound activity values for these units are unknown, but obviously greater than zero.

4.2.2 Equipment HP Estimates

Confidence intervals were calculated for equipment hp estimates for each equipment/fuel type combination, and are presented as a percent of the statewide averages in Table 84. Equipment categories for which confidence intervals could not be calculated (having only one observation in the survey data set) are not presented.

Table 84. 95% Confidence Intervals - Estimated Statewide HP Estimates

Equipment Type	Fuel Type	# Survey Observations*	Weighted Average HP	95% Interval (% of Average)
Aerial Lifts	Diesel	2	49	1,099%
Agricultural Mowers	Diesel	6	33	63%
Agricultural Mowers	Gasoline	17	22	17%
Agricultural Tractors	Compressed Gas	4	56	67%
Agricultural Tractors	Diesel	845	63	3%
Agricultural Tractors	Gasoline	73	35	17%

Equipment Type	Fuel Type	# Survey Observations*	Weighted Average HP	95% Interval (% of Average)
Air Compressors	Diesel	26	33	30%
Air Compressors	Gasoline	69	17	30%
All Terrain Vehicles	Diesel	6	19	88%
All Terrain Vehicles	Gasoline	71	48	26%
Balers	Diesel	15	72	25%
Bore/Drill Rigs	Diesel	10	127	15%
Bore/Drill Rigs	Gasoline	2	82	1,000%
Cement and Mortar Mixers	Gasoline	4	6	50%
Chainsaws	Gasoline	88	5	7%
Chippers/Stump Grinders	Diesel	2	39	679%
Chippers/Stump Grinders	Gasoline	4	8	54%
Combines	Diesel	21	125	20%
Concrete/Industrial Saws	Gasoline	5	6	119%
Cranes	Diesel	3	150	0%
Crawler Tractors	Diesel	11	147	12%
Crawler Tractors	Gasoline	2	7	994%
Excavators	Diesel	21	85	32%
Industrial forklifts	Compressed Gas	154	61	10%
Industrial forklifts	Diesel	28	70	23%
Industrial forklifts	Gasoline	28	74	17%
Front/Riding Mowers	Diesel	4	22	43%
Front/Riding Mowers	Gasoline	41	15	17%
Generator Sets	Compressed Gas	2	6	0%
Generator Sets	Diesel	8	46	86%
Generator Sets	Gasoline	98	12	24%
Golf Carts	Gasoline	2	23	141%
Graders	Diesel	12	88	20%
Irrigation Sets	Diesel	2	143	245%
Lawn Mowers	Gasoline	196	5	4%
Leaf Blowers/Vacuums	Gasoline	33	7	29%
Minibikes	Gasoline	2	19	930%
Off-Road Motorcycles	Gasoline	15	44	40%
Personal Water Craft	Gasoline	4	139	20%
Pressure Washers	Gasoline	24	7	31%
Pumps	Diesel	9	81	44%
Pumps	Gasoline	17	8	25%
Rollers	Diesel	16	49	40%
Rollers	Gasoline	4	5	7%
Rubber Tired Loaders	Diesel	47	82	10%

Equipment Type	Fuel Type	# Survey Observations*	Weighted Average HP	95% Interval (% of Average)
Rubber Tired Loaders	Gasoline	4	24	35%
Scrapers	Diesel	3	133	45%
Shredders	Gasoline	6	6	58%
Skid Steer Loaders	Diesel	28	62	13%
Skidders	Diesel	7	147	11%
Snowblowers	Gasoline	6	8	31%
Snowmobiles	Gasoline	4	40	0%
Specialty Vehicles Carts	Gasoline	2	77	1,181%
Sprayers	Diesel	19	76	20%
Sprayers	Gasoline	33	26	47%
Swathers	Diesel	5	112	27%
Tillers	Gasoline	18	6	11%
Tractors/Loaders/Backhoes	Diesel	117	59	7%
Tractors/Loaders/Backhoes	Gasoline	7	19	69%
Transport Refrigeration Units	Gasoline	130	50	0%
Trenchers	Gasoline	3	9	84%
Trimmers/Edgers/Brush Cutters	Gasoline	102	5	15%
Vessels w/Outboard Engines	Gasoline	6	36	63%
Welders	Diesel	2	94	892%
Welders	Gasoline	8	14	93%
Wood Splitters	Gasoline	2	9	684%

* unweighted counts of records with hp data – all survey sectors

As discussed with the activity data, a few equipment/fuel type combinations had no variation in reported hp values. These included categories with a small number of observations in the survey data: diesel cranes, compressed gas generator sets, and gasoline snowmobiles. The 130 TRUs reported by a single respondent were also identical in hp. Considering these factors confidence intervals cannot be accurately determined for these equipment categories.

The variance in hp values was generally smaller than found for reported activity values. Accordingly, a substantially higher number of equipment categories had 95% confidence intervals less than or equal to 50% of the mean value (41 of 66 categories). Similarly, only 11 categories had confidence intervals greater than 100%, none of which had more than 10 observations in the data set. Again, the actual lower bound hp for these equipment types is unknown.

4.2.3 Equipment Population Estimates

Confidence intervals were calculated for the estimated average number of equipment pieces owned or operated per establishment (or other appropriate surrogate value), for each of the four survey sectors, based on the equipment counts reported by each respondent. Average ownership rates (per thousand units) are provided in Tables 65 – 68, and account for establishments that did

not own or operate targeted equipment types as well as those that did. As seen in these tables, the average number of equipment pieces per acre, establishment, or household (depending upon the sector), are quite low, typically a fraction much less than one. In other words, the peak of the equipment count distribution for any particular equipment/fuel type combination was almost always zero, with a sharp drop off for successively higher equipment counts.

Given the highly skewed nature of the equipment count distributions, the above stated assumption regarding normality of the estimated means is uncertain. It is common for distributions involving counts to follow a Poisson distribution.(15) If it were determined that the reported equipment counts followed a Poisson distribution then adjustments could be made to the data to correct for non-normality, allowing us to continue to use Equation 1 in the determination of confidence intervals. Several key equipment types were evaluated to determine if their count distributions could be approximated by a Poisson function (diesel agricultural tractors, LPG industrial forklifts, gasoline generator sets, among others).[19] However, tests for these data clearly indicated that they were not approximated by Poisson distributions. No other non-normal distributions were evaluated, and the analysis proceeded under the assumption of normality for the mean equipment count estimates.

Since equipment count frequency varies substantially across survey sectors, 95% confidence intervals were calculated individually for each sector. Confidence intervals could not be calculated for equipment/fuel type combinations with only one observation within a sector, since the degrees of freedom for the t-test value equals zero. Accordingly, these equipment categories were assumed to have de minimus populations within that sector.

Once confidence intervals were calculated, sector-level population estimates from Tables 59, 61, 63 and 64 were applied to establish upper and lower bound population estimates for each sector. Because average population counts were so close to zero for most equipment categories, the calculated confidence interval was often greater than 100% of the mean, resulting in a negative population estimate for the lower bound. In these cases the lower population bound was set to zero for the purposes of statewide aggregation.

The upper and lower bound equipment counts were then summed across sectors in order to provide a final statewide equipment count interval. Upper and lower bounds for the statewide population estimates are provided in Table 85 for those equipment types for which sector-level confidence intervals could be calculated. Aggregated lower bound confidence intervals with zero values are not appropriate and are not reported in the table. Note that the final confidence intervals are not necessarily symmetrical, even for those equipment types with positive lower bound estimates, since lower bounds within certain sectors may have been set to zero.

[19] Poisson distributions have the interesting property that the variance is equal to the mean, allowing for relatively straightforward identification of these distributions.

Table 85. 95% Confidence Intervals - Estimated Statewide Equipment Population

Equipment Type	Fuel Type	Upper Bound	Lower Bound
Aerial Lifts	Diesel	139%	-
Agricultural Mowers	Diesel	88%	88%
Agricultural Mowers	Gasoline	104%	-
Agricultural Tractors	Compressed Gas	120%	-
Agricultural Tractors	Diesel	36%	34%
Agricultural Tractors	Gasoline	109%	94%
Air Compressors	Diesel	74%	66%
Air Compressors	Gasoline	55%	55%
All Terrain Vehicles	Diesel	124%	-
All Terrain Vehicles	Gasoline	62%	61%
Balers	Diesel	77%	77%
Bore/Drill Rigs	Gasoline	146%	-
Cement and Mortar Mixers	Gasoline	146%	-
Chainsaws	Gasoline	29%	29%
Chippers/Stump Grinders	Gasoline	98%	98%
Combines	Diesel	87%	87%
Combines	Gasoline	155%	-
Concrete/Industrial Saws	Gasoline	118%	-
Crawler Tractors	Diesel	124%	-
Excavators	Diesel	74%	73%
Industrial forklifts	Compressed Gas	42%	42%
Industrial forklifts	Diesel	78%	77%
Industrial forklifts	Gasoline	50%	49%
Front/Riding Mowers	Diesel	120%	-
Front/Riding Mowers	Gasoline	39%	39%
Generator Sets	Compressed Gas	125%	-
Generator Sets	Diesel	111%	96%
Generator Sets	Gasoline	67%	66%
Golf Carts	Gasoline	146%	-
Graders	Diesel	90%	90%
Lawn Mowers	Gasoline	13%	13%
Leaf Blowers/Vacuums	Gasoline	34%	34%
Off-Road Motorcycles	Gasoline	66%	66%
Personal Water Craft	Gasoline	146%	-
Pressure Washers	Gasoline	88%	87%
Pumps	Diesel	117%	95%
Pumps	Gasoline	110%	-
Rollers	Diesel	98%	98%
Rollers	Gasoline	155%	-
Rubber Tired Loaders	Diesel	80%	80%
Scrapers	Diesel	146%	-
Shredders	Gasoline	104%	-
Skid Steer Loaders	Diesel	77%	74%
Skidders	Diesel	101%	-
Snowblowers	Gasoline	88%	88%

Equipment Type	Fuel Type	Upper Bound	Lower Bound
Specialty Vehicle Cart	Gasoline	139%	-
Sprayers	Diesel	86%	86%
Sprayers	Gasoline	54%	53%
Swathers	Diesel	72%	72%
Tillers	Gasoline	66%	66%
Tractors/Loaders/Backhoes	Diesel	81%	81%
Tractors/Loaders/Backhoes	Gasoline	139%	-
Trimmers/Edgers/Brush Cutters	Gasoline	25%	24%
Vessels w/Outboard Engines	Gasoline	84%	84%
Welders	Diesel	139%	-
Welders	Gasoline	126%	99%
Wood Splitters	Gasoline	139%	-

As indicated in the table, only eight equipment/fuel type categories had 95% confidence intervals less than 50%. These included diesel agricultural tractors, chainsaws, compressed gas and gasoline industrial forklifts, gasoline front/riding mowers, lawn mowers, leaf blowers and vacuums, and trimmers/edgers/brushcutters. On the other hand, 30 of the 62 equipment categories with adequate numbers of observations had upper bound confidence intervals greater than 100%.

4.3 Preemption Analysis

The 1990 amendments to the federal Clean Air Act preempt California control of emissions from new farm and construction equipment under 175 horsepower. These equipment types are defined as follows: 1) Construction equipment or vehicle means any internal combustion engine-powered machine primarily used in construction and located on commercial construction sites; 2) Farm equipment or vehicle means any internal combustion engine-powered machine primarily used in the commercial production and/or commercial harvesting of food, fiber, wood, or commercial organic products or for the processing of such products for further use on the farm.

The Air Resources Board has developed a detailed list of off-road equipment types under 175 hp that are considered to be construction or farm equipment.(16) As such, these equipment categories are federally preempted from emission control requirements by the state. Table 86 presents ARB's current list to determine preempt applications, which has been approved by the U.S. EPA.

Table 86. Current ARB List to Determine Preempt Off-road Applications

Equipment with Engines < 25 hp*, including*:
Aerial devices: vehicle mounted
Asphalt recycler/reclaimer, sealer
Augers: earth
Back-hoe
Backpack Compressors
Baler
Boring machines: portable line
Breakers: pavement and/or rock

Equipment with Engines < 25 hp, *including*:
Brush cutters/Clearing saws 40 cc and above (blade capable only)
Burners: bituminous equipment
Cable layers
Chainsaws 45 cc and above
Chippers
Cleaners: steam, sewer, barn
Compactor: roller/plate
Compressors
Concrete buggy, corer, screed, mixer, finishing equipment
Continuous Digger
Conveyors: portable
Crawler excavators
Crushers: stone
Cultivators: powered
Cutting machine
Debarker
Detassler
Drills
Dumper: small on-site
Dusters
Elevating work platforms
Farm loaders: front end
Feed conveyors
Fertilizer spreader
Forage box/Haulage and loading machine
Forklifts: diesel and/or rough terrain
Harvesters, crop
Jackhammer
Light towers
Mixers: mortar, plaster, grout
Mowing equipment: agricultural
Mud jack
Pavers: asphalt, curb and gutter
Pipe layer
Plows: vibratory
Post hole diggers
Power pack: hydraulic
Pruner: orchard
Pumps 40 cc and above
Rollers: trench
Sawmill: portable
Saws: concrete, masonry, cutoff
Screeners
Shredder/grinder
Signal boards: highway
Silo unloaders
Skidders
Skid-steer loaders
Specialized fruit/nut harvester

Equipment with Engines < 25 hp, *including*:
Sprayers: bituminous, concrete curing, crop, field
Stump cutters, grinders
Stumpbeater
Surfacing equipment
Swathers
Tampers and rammers
Tractor: compact utility
Trenchers
Troweling machines: concrete
Vibrators: concrete, finisher, roller
Welders
Well driller: portable
Wheel loaders

All equipment > = 25 hp, *excluding*:
Aircraft Ground Power
Baggage Handling
Forklifts that are neither rough terrain nor powered by diesel engines
Generator Sets
Mining Equipment not otherwise primarily used in the construction industry
Off-Highway Recreational Vehicles
Other Industrial Equipment
Refrigeration Units less than 50 horsepower
Scrubbers/Sweepers
Tow/Push
Turf Care Equipment

The application categories reported by survey respondents (see Tables 35 thru 38) were combined with activity and population projections to estimate the total number of equipment pieces by application type, as well as the total hours per year each equipment category participated in agricultural, construction, and other activities. Consistent with the definition of preempted equipment types, ATVs and off-road motorcycles that were identified as being used for management of agricultural properties were re-assigned to the Other category since management is not a production, harvesting, or processing activity. Similarly, a small number of welders were re-assigned from the Agricultural category to Other, and tampers/rammers were re-assigned to Construction applications, based on ERG's familiarity with these equipment types.

Statewide equipment counts were first grouped by preemption category, as shown in the "Population Basis" columns of Table 87. These columns indicate the percentage of the statewide equipment population reported to be engaged in agricultural, construction, or other activities, respectively. The "Activity Basis" columns show the results of summing total equipment hours across sectors and fuel types.

The final two columns in Table 87 provide the 95% confidence intervals (upper and lower bounds) for the annual activity estimates. Confidence intervals were calculated at the equipment type level by aggregating upper and lower bound ranges across the different fuel categories shown in Table 83. (As discussed above, confidence intervals are not necessarily symmetric

about the mean.) These estimates are shown to provide an indication of the uncertainty associated with the application distribution percentages shown in the Activity Basis columns.

Evaluating application distributions by population counts as well as by total hours of use allows us to identify those equipment types that may have a "bi-modal" use pattern. For example, from Table 87 it can be seen that the majority of generator sets are used in non-preempted applications (predominantly in the Residential sector). On the other hand, generator sets in the Residential sector are only operated 45 hours per year on average (see Table 45), while generator sets in the Construction sector average 345 hours per year (see Table 47). This disparity in use patterns depending upon the application results in higher total hours of use in the Construction sector, even though equipment counts are substantially higher in the Residential sector. A similar pattern of ownership and use may be found in the pump category, in this case with the majority of the activity occurring in the Agricultural rather than the Construction sector. Thus, by first evaluating preemption status on an equipment count basis we can identify certain equipment categories (such as generator sets) that are predominantly outside the preempted categories, even though determinations based on total hours of use would indicate otherwise.

In the majority of instances the population and activity-based application distributions are consistent with one another, as well as with the existing preemption list. For example, several specialty agricultural and construction equipment categories indicate 100% of their activity occurs in their respective sectors, including balers, combines, irrigation sets and swathers (for agricultural applications); concrete/industrial saws, pavers and paving equipment, rollers, and signal boards (for construction applications). Other currently preempted equipment was found to have very high agricultural or construction application percentages, on both a population and application basis (e.g., excavators at 95%+ construction application). Similarly, currently non-preempted equipment categories frequently had very high percentages in the "Other" category, corresponding to high ownership and/or utilization in non-preempted business or residential applications. These include industrial forklifts, TRUs, and essentially all lawn and garden and recreational equipment categories.[20]

[20] A small number of chainsaws were reported to be used in agricultural applications, which may be used in logging. These units may correspond to the preempted chainsaws greater than 45 cc, as shown in Table 86, although the study survey did not obtain adequate responses regarding engine displacement in order to make this determination.

Table 87. Equipment Population and Activity Distributions by Application Category for Estimated Statewide Equipment Totals

Equipment Type	Population Basis			Activity Basis			95% Activity CI - High	95% Activity CI - Low
	Ag.	Const.	Other	Ag.	Const.	Other		
Aerial Lifts	6%	28%	66%	15%	31%	54%	407%	75%
Agricultural Mowers	51%	0%	49%	48%	0%	52%	40%	39%
Agricultural Tractors	79%	2%	20%	90%	0%	10%	14%	13%
Air Compressors	0%	61%	39%	0%	89%	11%	51%	47%
All Terrain Vehicles	0%	0%	100%	0%	0%	100%	27%	27%
Balers	100%	0%	0%	100%	0%	0%	50%	50%
Bore/Drill Rigs	0%	46%	54%	0%	99%	1%	24%	21%
Cement and Mortar Mixers	0%	23%	77%	0%	97%	3%	92%	53%
Chainsaws	1%	6%	93%	2%	8%	90%	38%	38%
Chippers/Stump Grinders	0%	0%	100%	0%	0%	100%	10%	4%
Combines	100%	0%	0%	100%	0%	0%	40%	37%
Concrete/Industrial Saws	0%	100%	0%	0%	100%	0%	1,093%	100%
Cranes	23%	77%	0%	1%	99%	0%	107%	100%
Crawler Tractors	15%	84%	1%	10%	81%	9%	109%	64%
Excavators	2%	98%	0%	5%	95%	0%	53%	53%
Industrial forklifts	10%	2%	88%	1%	<1%	98%	25%	25%
Front/Riding Mowers	5%	0%	95%	1%	0%	99%	66%	59%
Generator Sets	7%	28%	65%	1%	75%	24%	41%	40%
Golf Carts	0%	0%	100%	0%	0%	100%	154%	100%
Graders	22%	40%	37%	28%	71%	1%	139%	100%
Irrigation Sets	100%	0%	0%	100%	0%	0%	545%	100%
Lawn Mowers	4%	1%	95%	2%	<1%	98%	39%	39%
Leaf Blowers/Vacuums	2%	0%	98%	<1%	0%	100%	104%	100%
Minibikes	0%	0%	100%	0%	0%	100%	-	-
Off-Road Motorcycles	0%	0%	100%	0%	0%	100%	116%	100%
Pavers	0%	100%	0%	0%	100%	0%	-	-
Paving Equipment	0%	100%	0%	0%	100%	0%	-	-
Personal Water Craft	0%	0%	100%	0%	0%	100%	56%	56%
Pressure Washers	0%	14%	86%	0%	40%	60%	89%	89%
Pumps	32%	14%	54%	58%	33%	9%	54%	54%

Equipment Type	Population Basis			Activity Basis			95% Activity CI - High	95% Activity CI - Low
	Ag.	Const.	Other	Ag.	Const.	Other		
Rollers	0%	100%	0%	0%	100%	0%	97%	97%
Rubber Tired Loaders	44%	30%	26%	86%	9%	5%	38%	37%
Scrapers	0%	50%	50%	0%	99%	1%	134%	100%
Shredders	0%	0%	100%	0%	0%	100%	168%	100%
Signal Boards	0%	100%	0%	0%	100%	0%	-	-
Skid Steer Loaders	4%	61%	34%	19%	46%	35%	53%	53%
Skidders	60%	0%	40%	51%	0%	49%	62%	62%
Snowblowers	0%	0%	100%	0%	0%	100%	67%	67%
Snowmobiles	0%	0%	100%	0%	0%	100%	80%	80%
Specialty Vehicles Carts	0%	0%	100%	0%	0%	100%	-	-
Sprayers	87%	5%	8%	60%	38%	2%	40%	40%
Swathers	100%	0%	0%	100%	0%	0%	120%	99%
Tampers/Rammers	0%	100%	0%	0%	100%	0%	-	-
Tillers	1%	0%	99%	1%	0%	99%	66%	66%
Tractors/Loaders/Backhoes	13%	40%	47%	1%	43%	56%	26%	26%
Transport Refrigeration Units	0%	0%	100%	0%	0%	100%	-	-
Trenchers	100%	0%	0%	100%	0%	0%	229%	21%
Trimmers/Edgers/Brush Cutters	4%	1%	95%	6%	<1%	94%	56%	39%
Vessels w/Outboard Engines	0%	0%	100%	0%	0%	100%	159%	100%
Welders	0%	38%	61%	0%	43%	57%	16%	14%
Wood Splitters	100%	0%	0%	100%	0%	0%	-	-

However, in addition to the generator sets discussed above, disparities were found between the population and activity-based application distributions for other equipment categories. Bore/drill rigs, cement and mortar mixers, and scrapers were all estimated to have the majority of their equipment in non-preempted applications, although the vast majority of their hours of use were dedicated to construction activities. (The author of this report has encountered small cement and mortar mixers in the Residential sector, used for home projects such as patio or walkway installation. Though anecdotal, such uses may explain the high population/low utilization pattern for this equipment in the "Other" application category. Similarly, bore/drill units are also commonly used for non-construction activities such as water well drilling, telephone pole installation, mining, and oil and gas exploration support. The author is not aware of possible uses for scrapers outside the construction industry, however.)

Other equipment categories also showed discrepancies between the population and activity-based preemption assessments, leading to unexpected conclusions. For instance, while the tractors/loaders/backhoes category had the majority of its population in preempted categories, the majority of its activity was estimated to occur outside the construction and agricultural sectors. In addition, agricultural mowers, which show only a slight population majority in actual Agricultural applications, conversely show a slight majority in non-preempted applications when assessed on an activity basis. However, in this case the shift is quite small in relative terms, swinging by only three percentage points. Final determinations regarding these and other equipment categories should be made in light of uncertainty analysis results, as discussed below.

While their ultimate preemption status would remain unaffected, a small number of application distributions indicated unexpected or anomalous use patterns. For example, skidders were found to have non-trivial use in non-Agricultural applications (40% on a population basis). Skidders are specialty logging equipment (included under Agricultural production). While this equipment could be used for land clearing purposes, the author is not aware of other uses outside of the logging industry. Other equipment categories with an unexpectedly high Agricultural application contribution included rubber tire loaders (at 86% of total activity), and trenchers (at 100% of activity). Since these equipment categories are commonly used in construction activities, this result is most likely due to the low response rates and correspondingly high uncertainty for these categories. Finally, while skid steer loaders did have the majority of their population and activity in preempted categories, a substantial amount was also estimated for non-preempted applications. This may result for skid steer use in applications such as landscaping and material handling, commonly found by the author in other studies.

Four equipment categories currently on the preemption list were estimated to have the majority of their population and activity in non-preempted applications. These include aerial lifts, chippers/stump grinders, shredders, and welders. While aerial lifts are estimated to have a substantial fraction of their population and activity within the Construction sector (28% and 31%, respectively), the majority of units and hours of use are estimated to occur in non-preempted applications. However, the number of aerial lifts reported in the actual survey was very small (four units, unweighted), and the corresponding activity uncertainty is very large – over 400% for the 95% upper confidence interval. As such, no definitive conclusion can be drawn regarding the actual application distribution for this equipment category.

The same situation holds for welders as well, which are estimated to have the majority of their population and hours of use in non-preempted applications. Unlike aerial lifts though, the confidence interval associated with the welders' average activity estimate is relatively tight (~ 15%). However, very few welders were actually reported by survey respondents, and the corresponding population confidence interval is 100% or more (see Table 85). Accordingly, the actual application distribution for welders is highly uncertain.

The application distributions for chippers/stump grinders and shredders are even more skewed, with 100% of their populations and hours of use estimated to occur in non-preempted categories. Again, both of these categories had very low survey incidence rates, as reflected in the population uncertainty estimates in Table 85, where both equipment types have confidence intervals of approximately 100%. Therefore any inferences regarding the preemption status of these equipment types is also highly uncertain.

Wood splitters were unique, having 100% of their population and activity assigned to agricultural production, even though this equipment category is not on the current preemption list. However, the extremely low number of wood splitters reported in the study survey lead to very high population uncertainty estimates. Activity data for this equipment was so limited that uncertainty could not even be estimated for total hours of use. Therefore the actual exemption status for wood splitters remains unknown.

Upon closer inspection of Table 86, a number of equipment categories had so few survey responses that uncertainty estimates could not even be calculated for hours or use. These include minibikes, pavers, paving equipment, signal boards, specialty vehicles/carts, tampers/rammers, TRUs, and wood splitters. An even larger number had upper bound confidence intervals of over 100%, including aerial lifts, concrete/industrial saws, cranes, crawler tractors, golf carts, graders, irrigation sets, leaf blowers/vacuums, off-road motorcycles, scrapers, shredders, swathers, trenchers, and recreational marine vessels. While many of these equipment types may be safely categorized based on common knowledge, the study results themselves cannot be used to confidently support a preemption determination for them.

Finally, the limitations of the survey data are also apparent in the complete absence of some common construction equipment categories such as rough terrain forklifts and surfacing equipment. A host of low population specialty equipment currently included in the preemption list were not observed either, including mud jacks, dusters, pruners, among dozens of others. Obviously preemption determinations cannot be made regarding these equipment types.

4.4 Instrumentation Data

As discussed in Section 3.2.2, instrumentation data was not collected according to a predetermined statistical sampling plan. As such, a formal statistical analysis of the data was not conducted, and no generalizations can be made regarding exhaust gas temperature distributions or equipment retrofit potentials for the construction fleet as a whole.

The cleaned electronic data from the instrumentation loggers has been provided to ARB for additional review and analysis at their discretion.

5.0 Summary and Conclusions

This study surveyed the off-road equipment fleet operating in California, collecting bottom-up information on equipment populations, fuel type, hp and model year distributions, annual hours of operation, seasonal activity distributions, and user applications. It is expected that much of this data, reflecting California-specific fleet and operating conditions, will provide a substantial improvement over the existing equipment and activity data developed using top-down estimation methods. Therefore much of the equipment population and activity profile data collected during the study may be integrated into ARB's OFFROAD emissions model, replacing the default data and thereby improving the state's emissions estimates for off-road sources. The equipment application data collected in the survey may also be used to update ARB's list of preempted off-road equipment types less than 175 hp. Finally, the engine instrumentation data collected during the project may serve as the basis for designing future studies to assess retrofit potentials among construction equipment operating in different applications across the state.

Initial identification of survey targets, as well as design and testing of a pilot survey mechanism were executed in Phase I of this study, with the findings detailed in the Phase I report.

Design and execution of the Phase II equipment survey and analysis of the results presented unique challenges. First, low ownership rates for many off-road equipment types made it difficult to identify large numbers of equipment pieces. (Low numbers of observations in turn increase the uncertainty associated with the equipment type profiles developed from the survey data.) Once eligible participants were identified, great care was taken to describe the survey clearly to respondents in order to encourage high levels of participation, as well as complete reporting of targeted equipment types. In addition, equipment category naming conventions proved difficult to standardize, given the number of different ways an end user may refer to their equipment. Extensive post-processing and QA were conducted, relying on make/model descriptions and expert judgment to assign equipment to appropriate OFFROAD categories, and to screen out those categories not included in the target survey population.

Nevertheless, an extensive data set was developed for various equipment/fuel type combinations, including a number of different equipment characteristic and operation parameters. Surrogates were identified for each survey sector and applied to the reported equipment counts to develop statewide equipment population and activity profiles. A detailed error analysis of the resulting profiles found the 95% confidence intervals for average hp and hours of operation were relatively tight for several key equipment categories. Although equipment population estimates had significantly greater uncertainty, reasonably accurate population, hp, and activity estimates may be obtained for diesel agricultural tractors, compressed gas industrial forklifts, and assorted residential lawn and garden equipment (chainsaws, lawn mowers, leaf blowers/vacuums, and trimmers/edgers/brushcutters.) Activity and hp data may be utilized for a number of other equipment categories as well, depending upon what confidence intervals are deemed acceptable by ARB.

Model year distributions may be updated based on the findings for some of the most common equipment types such as agricultural tractors and compressed gas industrial forklifts. The age distribution for diesel, and especially gasoline, agricultural tractors was particularly skewed toward older units, with the median age being more than 20 years old.

The fuel type distribution data may also provide useful updates to OFFROAD defaults. For example, diesel ATVs, which are not listed in OFFROAD, were clearly identified in multiple survey sectors, and subsequently confirmed via manufacturer websites. In addition, the prevalence of gasoline agricultural tractors apparent from the survey data is not reflected in the current OFFROAD values. For example, the gasoline fraction estimated for the Agricultural sector is about 10%, compared to less than 1% in OFFROAD.

The seasonality data collected during the survey indicated a substantial variation in activity levels over the year among agricultural, recreational, and lawn and garden equipment, and may provide a basis for updating the seasonal allocation factors within OFFROAD in the future. Geographic allocation factors have also been identified and developed to allow for the proportional distribution of statewide population estimates to the county level.

Comparison of the study's equipment population estimates with independent data sources (such as OFFROAD and EPA's NONROAD model estimates for California) led to the conclusion that there was a systematic under-reporting of many construction and recreational equipment categories. For example, of the more common construction equipment types, only rubber tire loaders and tractors/loaders/backhoes had population estimates 50% or more of that found in the emissions models. In addition, while certain industrial equipment categories appear well-represented (e.g., pressure washers and air compressors), others such as generator sets and welders appear to be substantially under-reported.

In addition, several specialty equipment categories were identified by a very low number of respondents, or not at all by the survey. More notable examples include: airport GSE, rough terrain forklifts, TRU, and surfacing equipment. In addition, certain end-user groups appear to be under-represented, namely commercial lawn and garden companies and public sector fleets. For instance, only four pieces of off-road equipment were identified in the entire public sector stratum within the Residual sector. As such, alternative data sources are likely needed for these equipment types and end users.

Uncertainty associated with both equipment populations and average activity levels make preemption determinations difficult for the different off-road equipment categories. While the majority of population and activity distributions appear consistent with ARB's current preemption list, a number of exceptions and issues were identified.

Procedures were developed to collect engine RPM and exhaust gas temperature data on over 70 pieces of construction equipment. Data loggers were installed in the field for a period of one week for each piece of equipment included in the study. Common equipment types included backhoes, loaders, and excavators in both public and private operation. Engine on-time covered a broad range, from a few hours on a single day, to heavy use over five or more days during the week. Exhaust gas temperature profiles were highly variable as well, even within the same equipment category. Modal values for exhaust temperature ranged from approximately 200 to over 500 degrees Celsius. Temperature distributions also varied, with some equipment operated over a tight range, while others exhibited broad, even bimodal profiles. Accordingly, generalizations about engine operation time and exhaust gas temperature distributions could not be made regarding the construction fleet in California, or even regarding the specific equipment

types instrumented for this survey. However, the data may be used to screen for candidates for further testing in the future.

6.0 Recommendations

ERG developed a list of recommendations for utilizing and building upon the findings of this study, as described below.

1. *Integrate the population, activity, and hp distribution data for diesel agricultural tractors, compressed gas industrial forklifts, and possibly other equipment categories with robust response rates into the OFFROAD model.* The current data set most likely contains the most comprehensive profile of in-use diesel agricultural tractors in the country, and should be utilized to the greatest extent possible. While not as extensive, large numbers of observations are also available for compressed gas industrial forklifts, residential lawn mowers, residential chainsaws, air compressors, tractors/loaders/backhoes, ATVs, sprayers, and generator sets.
2. *Review confidence interval by equipment category for average hp and activity estimates.* ARB should establish reasonable limits for 95% confidence intervals and adopt the average hp and activity estimates within those limits.
3. *Consider adopting model year distributions for diesel and gasoline agricultural tractors.* The large number of agricultural tractor observations in the data set should allow for an accurate age profile to be developed at the state level. Smoothing of the model year data may still be required in order to obtain a reasonably continuous scrappage function. Development of a unique scrappage curve for agricultural tractors should be performed to account for their extreme age compared with other equipment types.
4. *Conduct a targeted assessment of construction equipment populations and activity profiles.* ERG has found the construction industry to be consistently difficult to profile through standard phone surveys. Alternative strategies should be investigated, including use of UCC-1 equipment sales transaction data to estimate hp and model year distributions, and possibly in-use populations for this equipment. Activity data may be obtained from engine clock hour data available from shop records and/or rental companies.
5. *Conduct a similar targeted assessment for recreational equipment populations and activity profiles.* Alternative strategies for these equipment types might include evaluation of recreational marine equipment registration data, or boat launch observations at selected locations across the state. This equipment is also particularly likely to be used in areas of the state different from where they are domiciled. Therefore these surveys should inquire specifically about use locations as well.
6. *Utilize the findings from other studies of specialty equipment categories and/or end-user categories*. We recommend integrating the findings from several previous studies to supplement the findings from the current effort. Such studies have been performed by ARB and others for TRUs, agricultural pumps, commercial lawn and garden equipment, publicly-operated off-road fleets, and possibly GSE.

7. *Adopt the geographic allocation factors developed for the different survey sectors.* Geographic allocation factors have been tailored to the different survey sectors and represent the most up-to-date data available concerning the distribution of surrogates at the county level.

8. *Consider adopting seasonal allocation factors for agricultural and residential lawn and garden equipment.* These data are likely representative of high-level activity patterns in these different sectors, and could be applied to multiple equipment/fuel type combinations.

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Glossary of Terms, Abbreviations, and Symbols

ARB – Air Resources Board
ATV – All Terrain Vehicle
CAFO – Concentrated Animal Feeding Operation(s)
CREE - California Regional Economies Employment series
EDMS - Emission Dispersion and Modeling System
EPA – Environmental Protection Agency
ERG – Eastern Research Group (prime contractor)
FAA - Federal Aviation Administration
GSE – Ground Support Equipment
HP – Horsepower
LPG – Liquefied Petroleum Gas (Propane)
NONROAD – USEPA emission factor model for off-road equipment
NOx – Nitrogen Oxides
OFFROAD – California ARB emission factor model for off-road equipment
PSR – Power Systems Research
RPM – engine Revolutions per Minute
SAS – Statistical Analysis Software
SIC – Standard Industrial Classification
SJV – San Joaquin Valley
SORE – Small Off-road Engine rulemaking
SSI – Survey Sampling International
TCEQ – Texas Commission on Environmental Quality
TRU – Transportation Refrigeration Unit
UCC-1 – Uniform Commercial Code (equipment sales record required for all financed transactions in the U.S.)
USDA – United States Department of Agriculture

Appendix A
Crop Type Assignments for Agriculture Sector

Crop	Crop Type
Almonds	Nut Crop
Chestnuts	Nut Crop
Macadamia	Nut Crop
Nuts (S)	Nut Crop
Nuts Other/Non-Specific	Nut Crop
Pecans	Nut Crop
Pistachios	Nut Crop
Walnuts	Nut Crop
(Turf and Ornamental) Golf Course - Military	Other Crop
(Turf and Ornamental) Golf Course - Private	Other Crop
(Turf and Ornamental) Golf Course - Public	Other Crop
(Turf and Ornamental) Golf Course - Resort	Other Crop
(Turf and Ornamental) Landscape - Contract	Other Crop
(Turf and Ornamental) Landscape - Architect	Other Crop
(Turf and Ornamental) Lawn Maintenance	Other Crop
(Turf and Ornamental) Memorial Park	Other Crop
Berries Other/Non-Specific	Other Crop
Blackberries	Other Crop
Blueberries	Other Crop
Cascadeberries	Other Crop
Cranberries	Other Crop
Foliage	Other Crop
Fruit (S)	Other Crop
Fruit Other/Non-Specific	Other Crop
Gooseberries	Other Crop
Grass	Other Crop
Huckleberries	Other Crop
Loganberries	Other Crop
Marionberries	Other Crop
Mushrooms	Other Crop
Nurseries Other/Non-Specific	Other Crop
Nurseries Retail	Other Crop
Nurseries Wholesale	Other Crop
Office Park	Other Crop
Oil Crops (S)	Other Crop
Oil Crops Other/Non-Specific	Other Crop
Passion Fruit	Other Crop
Raspberries	Other Crop
Seed	Other Crop
Sod & Sodding Service	Other Crop
Strawberries	Other Crop
Tropical Fruit (S)	Other Crop
Tropical Fruit Other/Non-Specific	Other Crop
Turf & Ornamental (S)	Other Crop
Turf & Ornamental Other/Nonspecific	Other Crop
Alfalfa	Row Crop

Crop	Crop Type
Artichokes	Row Crop
Asparagus	Row Crop
Barley	Row Crop
Beans Other/Fresh	Row Crop
Broccoli	Row Crop
Brussel Sprouts	Row Crop
Burley Tobacco	Row Crop
Cabbage	Row Crop
Canola	Row Crop
Carrots	Row Crop
Castor Beans	Row Crop
Cauliflower	Row Crop
Celery	Row Crop
Cigar Wrap/Filler	Row Crop
Clover	Row Crop
Corn/Soy - (S)	Row Crop
Cotton	Row Crop
Cucumbers	Row Crop
Dry Beans	Row Crop
Eggplant	Row Crop
Endive	Row Crop
Field Corn	Row Crop
Flax	Row Crop
Flowers	Row Crop
Flue Cured Tobacco	Row Crop
Garlic	Row Crop
Grain Sorghum	Row Crop
Green Beans	Row Crop
Hay (S)	Row Crop
Hay Other/Non-Specific	Row Crop
Herbs/Spice	Row Crop
Jojoba	Row Crop
Kale	Row Crop
Kohlrabi	Row Crop
Leeks	Row Crop
Legumes	Row Crop
Lespedezas	Row Crop
Lettuce	Row Crop
Lupine	Row Crop
Melons	Row Crop
Millet	Row Crop
Mixed Hay	Row Crop
Mustard Greens	Row Crop
Oats	Row Crop
Okra	Row Crop
Onions	Row Crop
Parsley	Row Crop

Crop	Crop Type
Parsnip	Row Crop
Peanuts	Row Crop
Peas	Row Crop
Peppers	Row Crop
Pop Corn	Row Crop
Potatoes	Row Crop
Pumpkin	Row Crop
Radish	Row Crop
Rhubarb	Row Crop
Rice	Row Crop
Rutabaga	Row Crop
Rye	Row Crop
Safflower	Row Crop
Small Grains Other/Non-specified	Row Crop
Small Grains (S)	Row Crop
Soybeans	Row Crop
Specialty Hay	Row Crop
Spinach	Row Crop
Squash	Row Crop
Sugarbeets	Row Crop
Sugarcane	Row Crop
Sunflower	Row Crop
Sweet Corn	Row Crop
Timothy	Row Crop
Tomatoes	Row Crop
Turnips	Row Crop
Vegetables (S)	Row Crop
Vegetables Other/Non-Specific	Row Crop
Vetch	Row Crop
Wheat	Row Crop
Yams/Sweet Potatoes	Row Crop
Apples	Tree Crop
Apricots	Tree Crop
Avocados	Tree Crop
Bananas	Tree Crop
Cherries	Tree Crop
Citrus (S)	Tree Crop
Citrus Other/Non-Specific	Tree Crop
Dates	Tree Crop
Figs	Tree Crop
Grapefruit	Tree Crop
Guava	Tree Crop
Kiwi	Tree Crop
Kumquat	Tree Crop
Lemons	Tree Crop
Limes	Tree Crop
Mangos	Tree Crop

Crop	Crop Type
Nectarines	Tree Crop
Olives	Tree Crop
Oranges	Tree Crop
Papaya	Tree Crop
Peaches	Tree Crop
Pears	Tree Crop
Persimmons	Tree Crop
Pineapple	Tree Crop
Pome Fruit (S)	Tree Crop
Pome Fruit Other/Non-Specific	Tree Crop
Pomegranate	Tree Crop
Prunes	Tree Crop
Quince	Tree Crop
Stone Fruit (S)	Tree Crop
Stone Fruit Other/Non-Specific	Tree Crop
Tangelos	Tree Crop
Tangerines	Tree Crop
Tree Fruit (S)	Tree Crop
Tree Fruit Other/Non-Specific	Tree Crop

Appendix B
SIC Codes by Survey Sector

Agricultural – Row Crops

SIC Code	Text Description
011	Cash Grains
013	Field Crops, Except Cash Grains

Agricultural – Nut Crops

0173	Tree Nuts
0179 (partial)	Fruits and Tree Nuts, Not Elsewhere Classified

Agricultural – Tree Fruit

0174	Citrus Fruits
0175	Deciduous Tree Fruits
0179 (partial)	Fruits and Tree Nuts, Not Elsewhere Classified

Agricultural – Other

0161	Vegetables and Melons
0171	Berry Crops
0172	Grapes
0191	General Farms, Primary Crop

Agricultural – CAFO/Dairy

021	Livestock, except Dairy and Poultry
024	Dairy Farms

Agricultural - Farm Management

0711	Soil Preparation Services
0721	Crop Planting, Cultivating and Protecting
0722	Crop Harvesting, Primarily by Machine
0762	Farm Management Services

Construction

15	Building construction general contractors and operative builders
16	Heavy construction other than building construction contractors
17	Construction special trade contractors

Mining

10	Metal Mining
12	Coal Mining
14	Mining and Quarrying of nonmetallic minerals except fuels

Logging

241	Logging

Residual (other)

Every SIC not grouped in Ag_Farm Management, Construction, Mining or Logging AND not in

one of the SICs listed below
4724 Travel Agencies
4725 Tour Operators
482: Telegraph And Other Message Communications
483: Radio And Television Broadcasting Stations
5441 Candy, Nut, and Confectionery Stores
5461 Retail Bakeries
5499 Miscellaneous Food Stores
Major Group 56: Apparel And Accessory Stores
5719 Miscellaneous home furnishings Stores
5735 Record and Prerecorded Tape Stores
5736 Musical Instrument Stores
Major Group 58: Eating And Drinking Places
Major Group 59: Miscellaneous Retail (EXCEPT INDUSTRY GROUP 598 - FUEL DEALERS)
Division H - Finance, Insurance, and Real Estate - Major Groups 60-65, 67)
Major Group 72: Personal Services (EXCEPT 7216 Drycleaning Plants)
Major Group 73: Business Services (EXCEPT Industry Group 734: Services To Dwellings And Other Buildings, AND Industry Group 735: Miscellaneous Equipment Rental And Leasing
7521 Automobile Parking
Major Group 76: Miscellaneous Repair Services
Industry Group 783: Motion Picture Theaters
Industry Group 784: Video Tape Rental
793: Bowling Centers
792: Theatrical Producers (except Motion Picture),
791: Dance Studios, Schools, And Halls
7993 Coin-Operated Amusement Devices
Major Group 80: Health Services
Major Group 81: Legal Services
Major Group 83: Social Services
8412 Museums and Art Galleries
Major Group 86: Membership Organizations
Major Group 87: Engineering, Accounting, Research, Management, And Related Services
Major Group 89: Miscellaneous Services
Industry Group 921: Courts
9222 Legal Counsel and Prosecution
Major Group 93: Public Finance, Taxation, And Monetary Policy
Major Group 94: Administration Of Human Resource Programs
Major Group 95: Administration Of Environmental Quality And Housing Programs
Major Group 96: Administration Of Economic Programs
9111 Executive Offices
9121 Legislative Bodies
9131 Executive and Legislative Offices Combined

Appendix C- Questionnaire
Designed for Telephone Administration

TELEPHONE QUESTIONNAIRE

ALL TEXT IN CAPS ARE PROGRAMMING OR INTERVIEWER NOTES AND ARE NOT READ TO THE RESPONDENT

INTRO 1

Hi, my name is [NAME] and I'm calling on behalf of NuStats. May I speak with [NAME OF CONTACT]?

INTRO 2

Hi my name is [NAME] and I'm calling on behalf of NuStats. We are conducting a survey with <business owners in the [Agriculture, Construction, Mining, Commercial] industry about the off-road equipment and off-road vehicles they use in their operations> OR <residents about the off-road equipment they own.> The information collected in the survey will provide more accurate data on off-road equipment used in California so that state air quality estimates can be updated. By off-road equipment or off-road vehicles, I mean any non-stationary device used or driven off the highways and powered by an internal combustion engine or electric motor including portable generators, as well as electric equipment, with a motor that is not typically driven on the road and is self-propelled. Other examples include: [READ EXAMPLES FROM LIST FOR SAMPLE TYPE].

<FOR AG SAMPLE TYPE ONLY: The Air Resources Board: with industry support from the California Cotton Ginners and Growers Associations, Nisei Farmers League, California Grape & Tree Fruit League, California Citrus Mutual, and the Fresno County Farm Bureau> is conducting this study. <Your business or your household> has been randomly selected at random to participate in this study. We would like to talk to the person <in your company or in your household> who is most knowledgeable about the off-road equipment you own or lease. Are you that person?

[IF YES, PROCEED; IF NO, ASK: CAN YOU REFER ME TO THE PERSON MOST KNOWLEDGEABLE ABOUT YOUR OFF-ROAD EQUIPMENT? WHEN CONTACT MADE WITH MOST KNOWLEDGEABLE PERSON START WITH INTRO 3]

INTRO 3—use if referred by owner/operator as "most knowledgeable person."

Hi my name is [NAME] and I'm calling on behalf of NuStats. We are conducting a survey with <business owners in the [Agriculture, Construction, Mining, Commercial] industry about the off-road equipment and machinery they use in their operations> OR <residents about the off-road equipment they own. The information collected in the survey will provide more accurate data on off-road equipment used in California so that state air quality estimates can be updated. <Name of Referral/Resident> is participating in this study and s/he referred us to you because are the person most knowledgeable about the off-road equipment owned or leased by <your company or

your household>. By off-road equipment or off-road vehicles, I mean any non-stationary device used or driven off the highways and powered by an internal combustion engine or electric motor including portable generators. Other examples include: [USE EXAMPLES FROM SIDE BAR FOR SAMPLE TYPE].

<FOR AG SAMPLE TYPE ONLY: The Air Resources Board with industry support from the California Cotton Ginners and Growers Associations, Nisei Farmers League, California Grape & Tree Fruit League, California Citrus Mutual, and the Fresno County Farm Bureau> is conducting this study.

START SURVEY.

SCREENING INTERVIEW
Sample (S) = A1 = Agriculture grower/farmer

First, I have a few general questions for you.

S1. How many pieces of motorized equipment do you own or lease that do not operate on the road? Examples include [USE EXAMPLES FROM SIDEBAR].

RECORD TOTAL_____	1	
NONE	2	TERMINATE
DK	9998	ASK FOR MORE KNOWLEGEABLE R AND REPEAT INTRO 2

S2. Does at least one of the pieces of equipment, whether owned or rented, have a maximum horsepower rating of less than 175hp?

YES	1	
NO	2	TERMINATE
DK	9998	ASK FOR MORE KNOWLEGEABLE R AND REPEAT INTRO 2

S3. ONLY ASK IF S=A1. How would you describe your primary Agriculture business activity?

Nut Crop	1
Row Crop	2
Tree Fruit (apricots, peaches)	3
Citrus Fruit (lemons, oranges, tangerines)	4
CAFO/diary	5
Vineyards	6

DK	9998 ASK FOR MORE KNOWLEGEABLE R AND REPEAT INTRO 2

S4. ASK IF S = A1. What is the total acreage of the land owned or leased by you?

OPEN RESPONSE: [RANGE = 0-99,999 ACRES]

S5. ASK IF S=A1.Would you consider your business to be a Farm Management Company?

YES	1
NO	2
DK	9998
RF	9999

EQUIPMENT AND USAGE

1. So that we have a complete list of the different types of equipment you own or lease, I'd like you to list each type and the number of each type you have. IF NEEDED< REFER TO EXAMPLES OF EQUIPMENT FOR SAMPLE TYPE]
SPECIFY TYPE AND NUMBER OF EACH TYPE

DK	9998

Now, for this last series of questions, I'm going to ask you about each type of equipment you just listed to me. This will take <INSERT TIME>

PROGRAMMER—THE FOLLOWING TIMES CORRESPOND THE NUMBER OF EQUIPMENT TYPES LISTED IN 1:

1 – 5	Less than 5 minutes
6-10	Less than 10 minutes
11-15	About 12 - 15 minutes
16 – 20	About 20 minutes
21 – 25	About 25 minutes
>26 – 30	About 30 minutes or longer

2. Let's start off with [EQUIPMENT TYPE].

A. What is the make of [EQUIPMENT TYPE] that you use the (next) most often?

OPEN RESPONSE

DK	9998
RF	9999

B. And what is the model name or number?

OPEN RESPONSE

DK	9998
RF	9999

C. How many [MAKE/MODEL] do you have?
OPEN RESPONSE [RANGE 1-999]

DK	9998
RF	9999

D. a. What work is the main type of work or activity you do with this type of equipment?
[PROGRAMMER NOTE: ROTATE RESPONSES]

Agricultural production, harvesting or processing	1
Building or construction	2
Warehousing	3
Automotive	4
Industrial	5
Recreational	6
Personal or residential	7
Other such as cleaning or maintenance (SPECIFY) 9997	
DK	9998
RF	9999

b. Okay, what percentage would that be, then?

SPECIFY PERCENTAGE [PROGRAMMER NOTE: IF MORE THAN ONE ALTERNATIVE ACTIVITY IS MENTIONED, CONTINUE ASKING Q.2D a AND b UNTIL PERCENTAGES ADD UP TO 100%. ONCE PERCENTAGE EQUALS 100% CONTINUE TO Q.4.F]

DK	9998
RF	9999

E. Okay, now let's focus on only your [MAKE/MODEL EQUIPMENT TYPE]. What is the model year you use the (next) most often?

OPEN RESPONSE

DK	9998
RF	9999

F. Now I'd like to know what is the horsepower and/or displacement?

a. Horsepower unit [SPECIFY UNIT]	SKIP TO Fc.
DK	9998
RF	9999

b. We don't need to know exactly, but just roughly, could you tell me if the equipment horsepower is….

Below 10	1
11 - 24	2
25 – 49	3
50 – 74	4
75 – 119	5
between 120 – 175	6
DK	9998
RF	9999

c. Now, how about the displacement? That would be in either cc's, liters, or cubic inches.

SPECIFY UNIT

DK	9998
RF	9999

G. And the fuel type? *[NOTE TO INTERVIEWER: ELECTRIC EQUIPMENT IS INCLUDED IN THE SURVEY]*

Diesel	1
Gasoline	2

Natural Gas	3
Propane	4
Electric	5
Other (SPECIFY)	9997
DK	9998
RF	9999

H. During 2005, how many hours did you operate the [MODEL/YEAR EQUIPMENT TYPE]? An estimate is okay.

OPEN RESPONSE

DK	9998
RF	9999

I. Now, I'd like you to estimate the percentage of time you use it on a seasonal basis. You said the total annual hours in 2005 were [2H RESPONSE], what would be the percentage of time you use it in Winter…..[INTERVIEWER: ASSIST WITH CALCULATING TO 100%; ON FALL, GIVE THEM THE FINAL PERCENTAGE. REPEAT ALL PERCENTAGES AND ASK FOR VERIFICATION.]

Winter—Jan-Feb-Mar (SPECIFY PERCENTAGE)

Spring—Apr-May-June (SPECIFY PERCENTAGE)

Summer—July-Aug-Sept (SPECIFY PERCENTAGE)

Fall—Oct-Nov-Dec (SPECIFY PERCENTAGE)

DK	9998
RF	9999

J. *[PROGRAMMER NOTE: INCLUDE FOR ALL SEASONS RECORDED IN I]* On average, how many days per week, do you typically use [MODEL/YEAR EQUIPMENT TYPE] during the [SEASON]? An estimate is okay. *[INTERVIEWER MAY NEED TO PROMPT RESPONDENT THIS INCLUDES WEEKENDS FOR A POSSIBLE TOTAL OF 7 DAYS.*

SPECIFY NUMBER [RANGE 1-7]

DK	9998
RF	9999

K. Is [MODEL YEAR EQUIPMENT TYPE] portable? That is, is the [MODEL YEAR EQUIPMENT TYPE] moved more than one per year, but is not self propelled?

YES	1
NO	2
DK	9888
RF	9999

L. Does that piece of equipment have wheels or is it a "crawler?"

WHEELED	1
CRAWLER	2
NEITHER	3
DK	9998
RF	9999

PROGRAMMER NOTE: WHEN INVENTORY FOR EACH EQUIPMENT TYPE AND MAKE/MODEL IS COMPLETED. GO TO TERMINATION 1.

TERMINATION: Thank you. That's all the questions I have for you today.

ASK IF SAMPLE = CONSTRUCTION INDUSTRY

We are also conducting a follow up study during which participants will agree to attach a recording device on one or more pieces of their off-road equipment for one week. The device measures activity and usage of the equipment by hour of the day and day of week and will be installed and removed by a trained technician.

I-1. May we call you about this follow up study?

YES	1	CONFIRM NAME/PHONE
NO	2	

Sample List of Off-road Equipment Types

1 2-wheel tractor(s)
2 Agricultural mower(s)
3 Agricultural tractor(s)
4 Air compressor(s)
5 All terrain vehicle(s)
6 Backhoe(s)
7 Bailer(s)
8 Brush cutter(s)
9 Bulldozer(s)
10 Chainsaw(s)
11 Chainsaw(s) (LT 5 hp)
12 Combine(s)
13 Drill(s)
14 Excavator(s)
15 Industrial forklift(s)
16 Generator set(s)
17 Grader(s)
18 Harvester(s)
19 Lawn edger(s)
20 Lawn mower(s) (walk behind)
21 Leaf blower(s) (back pack)
22 Loader(s)
23 Outboard engines
24 Panel Saw
25 Paving Equipment
26 Pipe Threading Machine
27 Pruning Tower
28 Pump(s)
29 Riding lawn mower(s)

30 Skid steer Loader(s)

31 Skidder(s)

32 Sprayer(s)

33 Snow blowers

34 Snow Mobiles

35 Sweeper(s)/Scrubber(s)

36 Table Saw

37 Tiller(s)

38 Tractor(s)

39 Transportation Refrigeration Unit(s)

40 Vertical Milling Machine

41 Vacuum

42 Water Truck(s)

43 Welder(s)

44 Other

Appendix D
Logger Installation and Retrieval Procedure

Procedures for Proper Cleaire MLC (Logger) Installation

GENERAL (updated Sep 2, 2007)

- Have trained operator demonstrate proper and safe engine startup and shutdown
- Ensure all necessary tools and consumables are at hand. (See list)
- Ensure MLC is complete (See list)
- Ensure the laptop available will communicate with the MLC properly.

Hardware Installation

- Find appropriate locations for all wiring, sensors and the MLC.
  - Does not hinder normal operation of equipment
  - Will not be damaged during normal operation
  - Does not impede operator vision
  - Does not look precarious or dangerous
  - Allows for laptop hookup to dongle on MLC in final installed location
  - Allows cable routing within length limitations of wiring harness
  - Allows safe cable routing.
  - Allows proper fastening of all wiring, sensors and MLC that withstand vibration of normal engine operation
- Always use Backpressure for 0-5 V analog (if needed).

Recommended Hardware installation order:

1. Install exhaust temperature sensor (T1)
   - Always use T1 for exhaust temperature sensing and T2 for ambient.
   - Secure exhaust thermocouple using wire and spring arrangement. Thermocouple should not touch inner wall of exhaust pipe and should enter into the pipe about 3 or 4 inches
   - Ensure un-insulated wire is far enough from hot exhaust. Use springs as standoffs, if necessary.

2.a. Install Idler Pulley RPM sensor (if no appropriate port exists in bell-housing of engine)

- Use RPM sensing wheel with dead-shaft and hall-effect sensor.
- Mount hinge with two large hose clamps around alternator. Use flat metal stock to reinforce hinge at contact surface with alternator.
- Make sure hinge rotates smoothly and
- Ensure sensor wheel contacts alternator belt as close to center of belt as possible. Adjust wheel offset if possible to center sensor wheel on belt.
- Ensure sensor wheel spins freely but adjust hall-effect sensor offset from wheel until sensor wheel indexes because of magnetic field of hall-effect sensor on metal tacks in sensor wheel.

2.b. Install Fly-Wheel RPM sensor

- Remove dust cap from threaded port in bell housing of engine. Store it in a safe spot on the vehicle where it can be retrieved during removal of the logger. Make not of the location of the plug in the installation sheet.

- Use a fine-thread bolt to clean any burrs from the port threads.
- Install the hall-effect sensor into the port and screw it gently in until it bottoms against the fly-wheel. Screw it back out ¼ turn (CCW). The body of the sensor much softer than the bell housing material and is easily cross-threaded.
- Temporarily connect the sensor to the MLC and check its signal when the engine is on. Disconnect the sensor from the MLC.

3. Pick MLC location with wire routing in mind.
4. Route wiring and connectors.
5. Connect power wires to battery.
   - Use crimp on eyelets.
   - Make sure positive lead has a 5amp fuse. Connect negative first.
   - Test voltage to eyelets after installing power wires.
6. Loosely zip tie components to allow safe initial testing of MLC and installed sensors.
   - Secure data logger with large zip ties in appropriate location. Leave loose until installation is QA'd.
   - Secure all wiring with zip ties. Leave loose until installation is QA'd.
   - Test vibration response of all equipment and wiring.
   - Ensure all equipment including wiring is out of the way of any moving or hot parts.
7. Run engine and use laptop to calibrate MLC rpm scale.
8. "Commission" the datalogger with appropriate information and configuration settings. Test setup with Software section of this SOP before "clean up" and tightening of hardware installation. Make appropriate changes if necessary (e.g., swap thermocouples or wires)
9. Finish install by adding and/or tightening zip ties and ensuring all wires and components are secured.

Software

If necessary, create a folder where data will be downloaded when this unit is de-installed. Save pictures and other files related to this install there. Use MLinC program to setup up the logging session. Remember to click "send to MLC" after changing information. Enter the following information (and write down for entry into spreadsheet):

- 'Engine Info' tab
  - Vehicle ID -- unique vehicle ID (e.g., owner ID number or engine number from emissions label.)
  - Customer – site name or vehicle owner (e.g., Davis, city of)
  - Product – Vehicle make & model (e.g., JD 310sg)
  - Technician Name – Your initials
  - Engine Hrs or Miles – engine hours from hour meter (typically in the cab)
  - Set Time and Date – set if necessary
  - Set RPM Scale – run the engine and compare reading to actual RPM. Adjust scale factor to ensure most accurate reading over entire engine RPM range. Use three RPM test points to calibrate; idle, midrange and maximum engine RPM. Record these data points in table provided on install form. Suggested scale factor of 22.
- 'Log' tab – If necessary
  - Fast download – to save data to laptop that is currently stored in MLC

- View the Instant Report. Save this information as a text file into the folder where data will be downloaded for this vehicle.

Using hyperterminal set these options with the 'config' command

- 1 Log Update Secs 2 ← set to 2
- 2 Logging Enabled 1 ← ensure logging enabled
- 3 Logging Verbose 1 ← use to test logging, not necessary if sensor reading confirmed in prior step with MLinC program
- 4 EV Logging Verbose 0
- 10 RPM Scale Factor 22 ← Set this in here. Use number found in MLinC software under 'Set RPM scale'. Hyperterminal will reliably save scale factor. Suggested scale factor 22.
- 11 RPM Log Threshold 200 ← adjust this only if using RPM log control
- 12 Log Turnoff Secs 10
- 13 Algorithm Select 0 ← not important for logging-only
- 16 T1 Log Threshold 60 ← set to 60
- 18 Log Control, 0-RPM, 1-T1 1 ← Use T1 for log control
- 19 Engine Disp 10 x L ## ← based on current engine displacement

After settings set with 'configx yy' then save all settings with 'cfgsave'. Close hyperterminal window and reopen to confirm config settings saved. Type "config" and "status" commands. Save the results to a file named 2007*mmdd*InstallConfig.txt" in the same folder where the data will be downloaded after the de-installation.

Maintain an active connection between the hyper terminal and the MLC to verify logging begins when engine is started. Start engine and wait for data to be logged. This should appear automatically if verbose logging is enabled. Run engine at idle for 30 seconds and then shut off. Watch data to make sure it seems reasonable.

Indicated RPM Calibration Curve Data

Target Engine RPM (rpm)	**Actual Engine RPM** (rpm)	**Relative Uncertainty** (+/- rpm)	**Logger RPM** (rpm)	**Relative Uncertainty** (+/- rpm)
Idle				
~1500				
~2500				

Checking an Installation

Visually inspect the RPM and thermocouple sensors. Establish communications with the MLC and watch the live data as the engine is running. Trouble shoot any problems. If de-installation is necessary before a 7 contiguous calendar days of proper logging, any vehicle should be found to replace the unfinished one. The replacement vehicle should be installed as if the unfinished vehicle had never been logged.

Hardware Un-install

After 7 contiguous calendar days of proper logging, begin un-install by downloading data from MLC to laptop. (Note: 7 days with engine activity are not required. The logger need only be installed for 7 days of proper logger installation and logger operation.)

1. Open MlinC program.
2. First ensure a working connection with the MlinC by reading both temperature readings in the "engine info" tab. Click the "read MLC" button a few times if necessary.
3. Check RPM sensor signal by spinning RPM sensor wheel by hand while watching for a reading on the "engine info" tab.
    a. If not reading any RPM signal; **download data without un-installing physical system**. Review data and insure one full calendar week of data that includes RPM readings.
    b. If there is one week of 'good' data; continue to step 4 of this un-install procedure.
    c. If there is not one week of 'good' data, replace RPM sensor with a known working sensor and follow install procedure to ensure a proper RPM reading. **Do not un-install the system.** Leave the system installed to get a complete week of data collection (including the good RPM data already collected).
4. Open MlinC program. Click on "log" tab. Then click on "fast download" button.

While download is taking place (approx. 15 minutes), physically remove sensors and wiring. **Be sure to leave the MLC connected to the battery while downloading data.**

1. Start with exhaust temperature sensor. Clip/cut the metal cable that secures the retaining springs to the exhaust pipe. Save springs for a later install.
2. Clip/cut all zip ties that secure the wiring.
3. Remove the rpm sensor second. While removing the large hose clamps from the alternator, be sure not to touch any exposed "positive" metal, wire, or bolts on the alternator.

After download is complete, convert the binary file into a text file using the MLinC software.

1. On the "log" tab, click the "view binary" button.
2. In the proceeding popup window (titled "Convert Binary to Text"), click the "browse" button.
3. Another popup window will open. Navigate to and select the .bin file of the recently downloaded data. Press the "open" button and the popup window will close.
4. Once a binary file is selected, press the "convert" button in the "Convert Binary to Text" popup window. The conversion takes about a minute and two text files will open when the conversion is finished.
5. Review the Text file with the time stamped raw sensor readings to ensure good RPM readings right up to the last logging time. Some judgment should be exercised to evaluate the information and to assume the information contains a week of "useful" data.

After checking the downloaded data log, finish physical un-installation by disconnecting the MLC from the battery. **Be careful not to ground out the Positive battery terminal or wires with your tools or your body**. Remove any remaining components of the Cleaire data logging system from the vehicle and collect all trash (e.g. zip tie or wire tie pieces).

Try to clean the wiring harness and the MLC before packing neatly back in the supplied box.

As soon as possible send a copy of the data to andrew.burnette@erg.com or save to another location, such as a flash drive.

Suggested Tools

- Wrenches (various sizes, ¼ to ¾ inch, open end)
- Wire cutters (nippers)
- Adjustable pliers and 'monkey' wrench
- Flat head and Philips screwdriver
- Utility knife
- Wire terminal crimp tool
- Multimeter with Ohms, VDC at least
- ¾ inch, fine thread bolt to clean out bell-housing port for RPM transducer
- 5/8 inch, fine thread bolt to clean out bell-housing port for RPM transducer

Consumables for Install

- Zip ties various sizes
- Locktite (non-permanent)
- Wire ringlet terminals for power/ground (male, female plug type and ring type)
- Electrical tape
- Springs (to secure exhaust temp thermocouple)
- Tie wire, metal braided (to secure exhaust temp thermocouple)
- Hose clamps for securing RPM sensor to alternator

MLC Logger Parts List

- MLC in box
- Umbilical for sensors with connectors for TC1, TC2, RPM, and MAP
- Umbilical for power with power terminals and serial data connector
- RPM sensors (1 and at least 1 back-up)
- Thermocouples (2 and at least 1 back-up)
- RPM/belt speed gadgets (1 and at least 1 back-up)

Appendix E
Public Fleets Contacted for Participation

Public Fleets contacted in the Sacramento Area												Construction Equipment in fleet		
CONTACT	BUSINESS	CITY	AREA CODE	PHONE NUMBER	NEW PHONE	NEW CONTACT	OLD CONTACT	EMAIL	Rings no answer	Discon-nected	Left a messg	Yes	No	Approx pieces of equipment
Phil Garthy	CALIFORNIA DEPARTMENT OF TRANSPORTATION	SACRAMENTO	916	6533442	227-6473	Phil Garthy	JEFF MORALES				X	X		around 770
Gordon Black	DISTRICT	GRASS VALLEY	530	273-6185		Gordon Black	ROBIN LANTZ					X		over 300
Dena Luis	CALIFORNIA DEPT OF FORESTRY AND FIRE PROTECTION	SACRAMENTO	916	3225684	653-8007 / 530-757-2407	Dena Luis	RICHARD WILSON		X			X		less than 200
BRIAN SMITH	SACRAMENTO MUNICIPAL UTILITY DISTRICT	SACRAMENTO	916	7325281				bsmith@smud.org				X		over 100
BRYON RUSH	CALIFORNIA DEPT OF WATER RESOURCES	SACRAMENTO	916	653-2950	653-5791/653-5020			brush@water.ca.gov	X	X		X		less than 50
MIKE NIGLIAZZO	CITY OF FAIRFIELD	FAIRFIELD	707	4287414								X		less than 50
EBEN STEVENS	DEPARTMENT OF TRANSPORTATION	FAIRFIELD	707	4216055								X		less than 50
GEACH	PLACER COUNTY	AUBURN	530	8897596				jgeach@placer.ca.gov				X		about 96
ROBERT BAILEY	CITY OF FOLSOM	FOLSOM	916	3557200	355-8343							X		less than 50
Jerry Foot	ELDORADO IRRIGATION DIST	PLACERVILLE	530	6224513	642-4046	Jerry Foot	WILLIAM WILKINS				X	X		around 30
Kevin	CITY OF ROCKLIN	ROCKLIN	916	6324000	625-5000	Kevin	CARLOS URRUTIA			X		X		less than 50
Utterback	SACRAMENTO	SACRAMENTO	916	6811039				utterbacks@saccounty.net			X	X		around 40
Frank Weber	SOLANO IRRIGATION DISTRICT	VACAVILLE	707	4486847		Frank Weber	ROBERT ISSAC					X		around 40
Paul Disenbach	CITY OF ROSEVILLE	ROSEVILLE	916	7745202	774-5654	Paul Disenbach	CAROLYN LYONS				X	X		around 30
CATES	CITY OF STOCKTON	STOCKTON	209	9377417				jerry.cates@ci.stockton.ca.us			X	X		18
Bob Schermer	CITY OF VACAVILLE	VACAVILLE	707	4495117		Bob Schermer	TERRY WOLFORD					X		around 18
JIM MACDONALD	CITY OF DAVIS	DAVIS	530	7575653				jmacdonald@ci.davis.ca.us				X		around 14
Mike	RECLAMATION DISTRICT NO. 1000	SACRAMENTO	916	9221449		Mike	J CLIFTON				X	X		less than 10
Leroy	COUNTY OF YUBA	MARYSVILLE	530	7416421	741-6537	Leroy	JAN CHRISTOFFERSON			X		X		less than 10
WINCHESTER	BROWNS VALLEY IRRIGATION DISTRICT	BROWNS VALLEY	530	7435703								X		less than 10

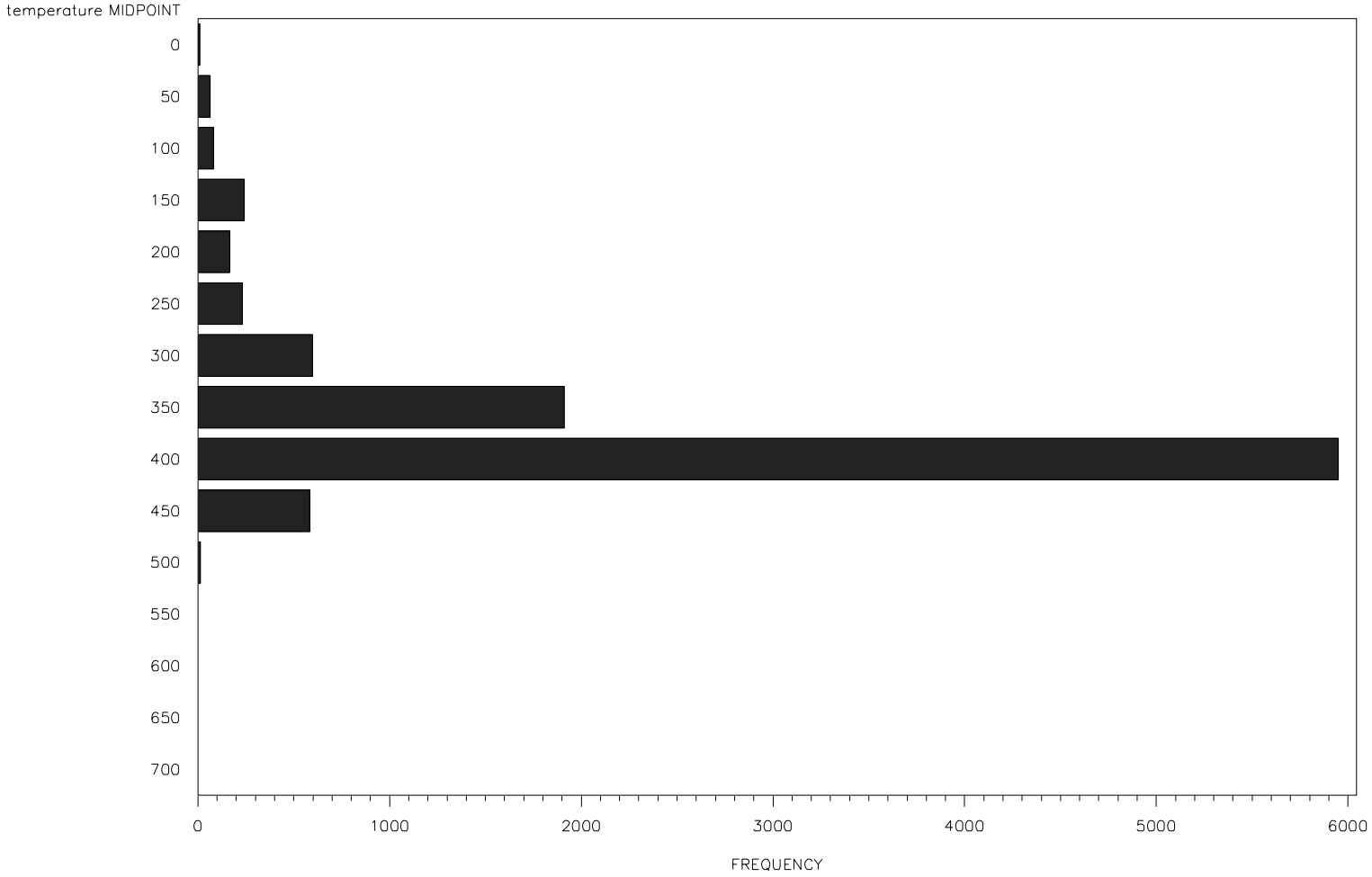
Public Fleets contacted in the Sacramento Area												Construction Equipment in fleet		
CONTACT	BUSINESS	CITY	AREA CODE	PHONE NUMBER	NEW PHONE	NEW CONTACT	OLD CONTACT	EMAIL	Rings no answer	Discon-nected	Left a messg	Yes	No	Approx pieces of equipment
Ray	SUTTER COUNTY MAINTENANCE SHOP	YUBA CITY	530	7417453	822-7453	Ray	KEN WALDEN			X	X	X		20
Jim Roberts	FORESTHILL UNION SCHOOL DISTRICT	FORESTHILL	530	3672966		Jim Roberts	Jim Roberts				X	X		Less than 10
Tom or Ken	CITY OF YUBA CITY	YUBA CITY	530	8224610	822-4646	Tom or Ken	JEFFREY FOLTZ				X	X		less than 20
	PLACER COUNTY WATER AGNCY	FORESTHILL			530-885-6917							X		less than 10
Dennise	CITY OF LODI	LODI	209	3336740	333-6800 ext. 2684	Dennise	RICHARD PRIMA					X		less than 10
CURTIS SIMPSON	CITY OF AUBURN - STATE OF CALIF	AUBURN	530	8234206								X		less thatn 10
JOHN TOWNSEL	CITRUS HEIGHTS IRRIGATION DISTRICT	CITRUS HEIGHTS	916	7256873								X		about 5
PAUL RUSSELL	SUTTER EXTENSION WATER DISTRICT	YUBA CITY	530	6737138								X		2
No response yet from this group...														
BAIR	DISTRICT	CARMICHAEL	916	483-2452				scott@carmichaelwd.org			X			
	DISTRICT	FAIR OAKS			967-5723						X			
GARY SCMAAF	AMADOR COUNTY PUBLIC WORKS	JACKSON	209	223-6429							X			
JOHN LANE	CALIFORNIA DEPARTMENT OF CORRECTIONS	SACRAMENTO	661	3361100	324-6919/445-7682					X				
RICHARD ANDREWS	CALIFORNIA OFFICE OF EMERGENCY SERVICES	SACRAMENTO	916	4274990	464-1024 Not able to speak with anyone.					X				
LEIGH KEICHER	CITY OF WEST SACRAMENTO	WEST SACRAMENTO	916	3735850	617-4500/617-4850					X				
KENNETH FRANK	CALIFORNIA DEPT OF PARKS AND RECREATION	SACRAMENTO	916	5259534	653-6995					X				
BEN BRAMER	CITY OF MARYSVILLE PUBLIC WORKS	MARYSVILLE	530	7416644	741-6633					X				
ROBERT SUMMERSET	CITY OF SACRAMENTO	SACRAMENTO	916	4336230	808-1869					X	X			
THOMAS ENGLE	COUNTY OF SACT DEPT OF AIRPORTS	SACRAMENTO	916	6480645	874-0616 Not able to speak with anyone.					X				
Daron Oakley	CALIF STATE UNIVERSITY, SACRAMENTO	SACRAMENTO	916	2785242	278-6421	Daron Oakley	R W MAC MCQUEEN				X			

Public Fleets contacted in the Sacramento Area												Construction Equipment in fleet		
CONTACT	BUSINESS	CITY	AREA CODE	PHONE NUMBER	NEW PHONE	NEW CONTACT	OLD CONTACT	EMAIL	Rings no answer	Discon-nected	Left a messg	Yes	No	Approx pieces of equipment
Richard Fitzhugh	CITY OF GRASS VALLEY	GRASS VALLEY	530	2744351	477-4620	Richard Fitzhugh	RUDI GOLNIK				X			
Randy Madison	CITY OF WOODLAND	WOODLAND	530	6615978	661-5956	Randy Madison	GERALD DAVIS				X			
DWIGHT HELMICK	CALIFORNIA HIGHWAY PATROL	SACRAMENTO	916	3763500							X			
WILLIAM STOKES	WOODBRIDGE IRRIGATION DISTRICT	WOODBRIDGE	209	3696808							X			
DENNY VEIGA	PLACER COUNTRY WATER AGENCY	AUBURN	530	8234868							X			
SCOTT STEWART	EL DORADO COUNTY SHERIFF	PLACERVILLE	530	6215894				stewarts@edso.org			X			
Bob Pyne	CITY OF PLACERVILLE	PLACERVILLE	530	6425232		Bob Pyne	BRIAN J NUNEZ				X			
Diane	RECLAMATION DISTRICT 1001	RIO OSO	530	6562318		Diane	DONALD WHITE				X			
Anthony Lopez	YOLO COUNTY FLOOD CONTROL & WATER CONSERVATION D	WOODLAND	530	6620265		Anthony Lopez	JAMES EAGAN				X			
SCOTT HOKAMA	SOUTHGATE REC & PARK DIST	SACRAMENTO	916	391-7687							X			
Bob	SACRAMENTO	SACRAMENTO	916	8755407							X			
DAN MILLER	SACRAMENTO	SACRAMENTO	916	8766471				millerd@saccounty.net			X			
No construction equipment from here down...														
TOM HARRAIS	TRI DELTA TRANSIT E CC TRANSIT AUTH	ANTIOCH	925	754-6622 x261				tharais@ecta.org					X	
NADINE TARADASH	EMPLOYMENT DEVELOPMENT	SACRAMENTO	916	654-8510				ntaradas@edd.ca.gov					X	
Beverly	DEPT MOTOR VEHICLES	SACRAMENTO			800-777-0133/916-657-9067	Beverly							X	
ROBERT HIGHT	CALIFORNIA DEPT OF FISH AND GAME	SACRAMENTO	916	6537344	653-4899					X			X	
BILL COLEMAN	SAN JOAQUIN COUNTY SHERIFFS DEPARTMENT	STOCKTON	209	9443235	468-3905					X			X	
Randall	CALIFORNIA-DAVIS ENVIRONMENTAL SVC	DAVIS	530	7526570	752-0787	Randall	VON BOTTOMS		X				X	
JULIE MCNEAL	UNIVERSITY OF CALIFORNIA	DAVIS	530	7521499									X	
DICK JONES	AUTHORITY	FOLSOM	916	3581734									X	

Public Fleets contacted in the Sacramento Area												Construction Equipment in fleet		
CONTACT	BUSINESS	CITY	AREA CODE	PHONE NUMBER	NEW PHONE	NEW CONTACT	OLD CONTACT	EMAIL	Rings no answer	Discon-nected	Left a messg	Yes	No	Approx pieces of equipment
ALFRED A NUNES	CITY OF JACKSON	JACKSON	209	2231646									X	
BRADLEY ARNOLD	SOUTH SUTTER WATER DISTRICT	TROWBRIDGE	530	6562242									X	
Terry	EL DORADO COUNTY ENVIRONMENTAL MANAGEMENT DEPARTME	PLACERVILLE	530	6215308	642-4906	Terry	JON MORGAN						X	
Cesar Galindo	YOLO COUNTY	WOODLAND	530	6668010	666-8031	Cesar Galindo	ROY PEDERSON						X	
PILKA ROBINSON	SACRAMENTO REGIONAL TRANSIT DISTRICT	SACRAMENTO	916	3212800									X	
FLEET MANAGER	REDEVELOPMENT AGENCY	SACRAMENTO	916	4401300	440-1345								X	
JOHN HILTON	CALIFORNIA DEPT OF GENERAL SERVICES	SACRAMENTO	916	5742242									X	
FLEET MANAGER	CALIFORNIA DEPT OF FOOD AND AGRICULTURE	SACRAMENTO	559	4455031									X	
JESSE GARCIA	CALIFORNIA DEPT OF YOUTH AUTHORITY	SACRAMENTO	209	2967581									X	
AL RAMBURO	CALIFORNIA CONSERVATION CORPS	SACRAMENTO	916	3249386									X	

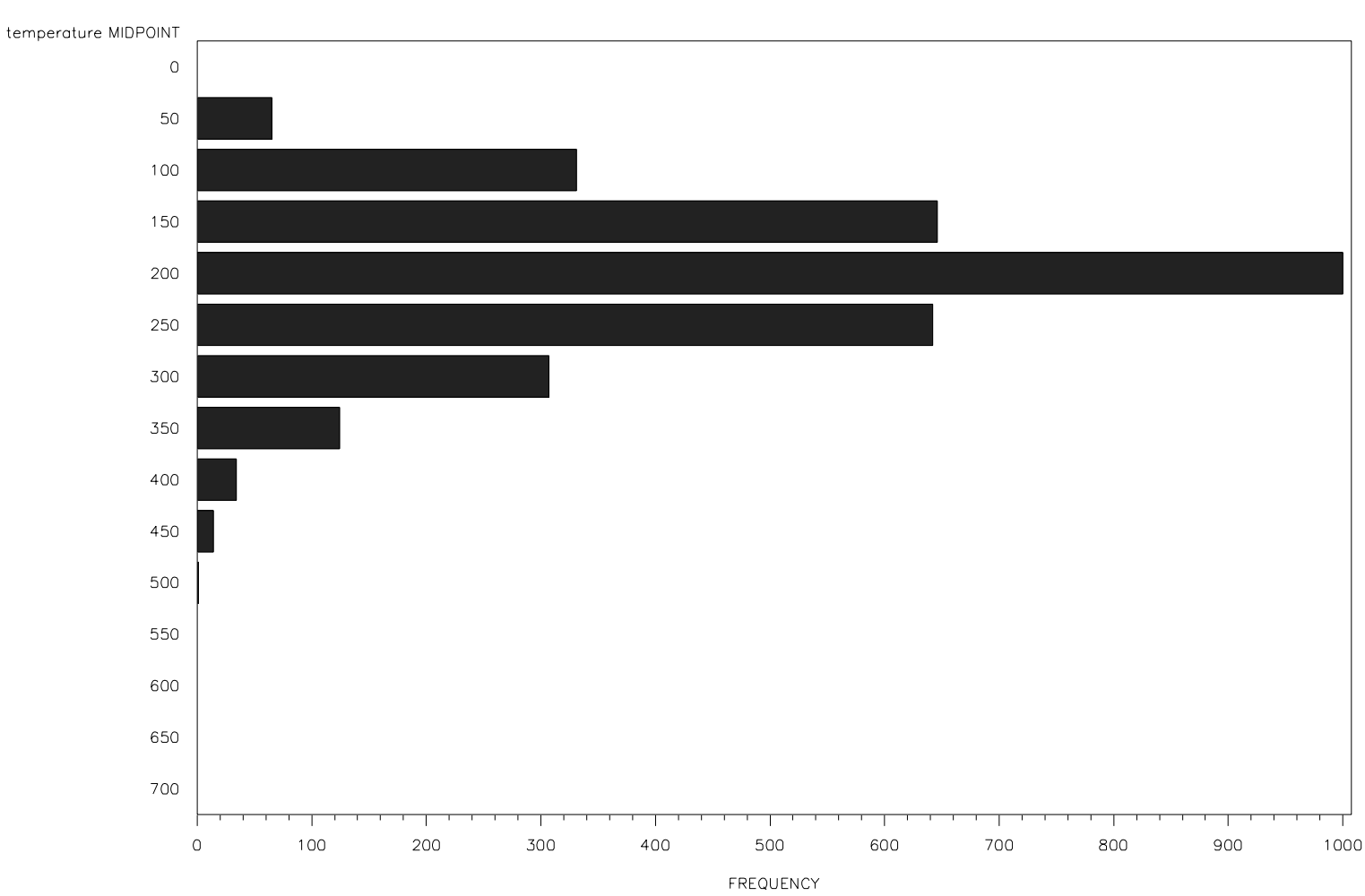
Appendix F
Instrumented Vehicle Exhaust Gas Temperature Profiles

Exhaust Gas Temperature
plotinfo=s20070401_1_Loader_KieferLandfill



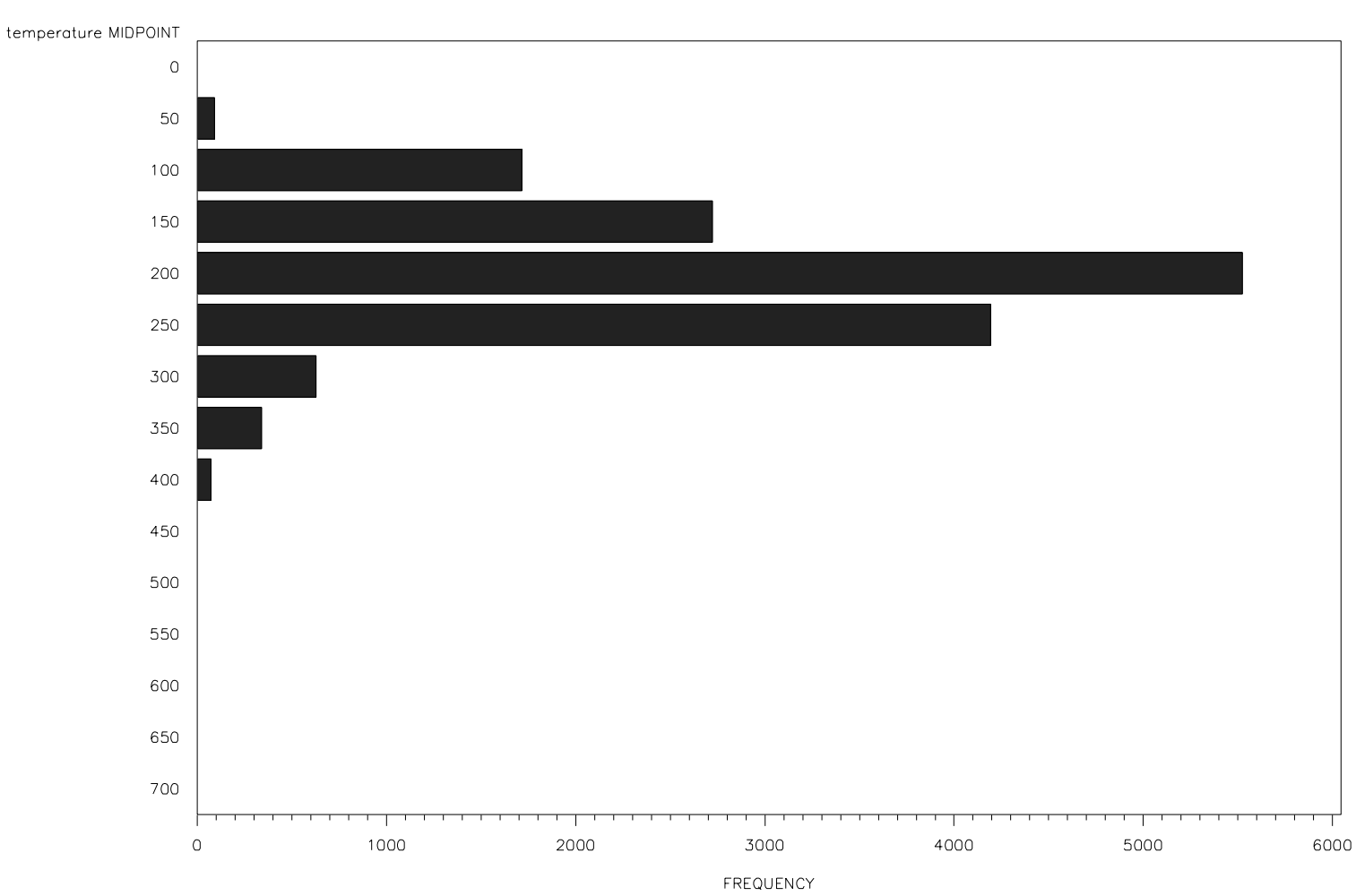
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	10	10	0.10	0.10
50	64	74	0.65	0.75
100	81	155	0.82	1.57
150	241	396	2.45	4.02
200	166	562	1.69	5.71
250	233	795	2.37	8.08
300	598	1393	6.07	14.15
350	1911	3304	19.41	33.56
400	5947	9251	60.41	93.97
450	582	9833	5.91	99.88
500	12	9845	0.12	100.00
550	0	9845	0.00	100.00
600	0	9845	0.00	100.00
650	0	9845	0.00	100.00
700	0	9845	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070503_1_Loader_59thStYard



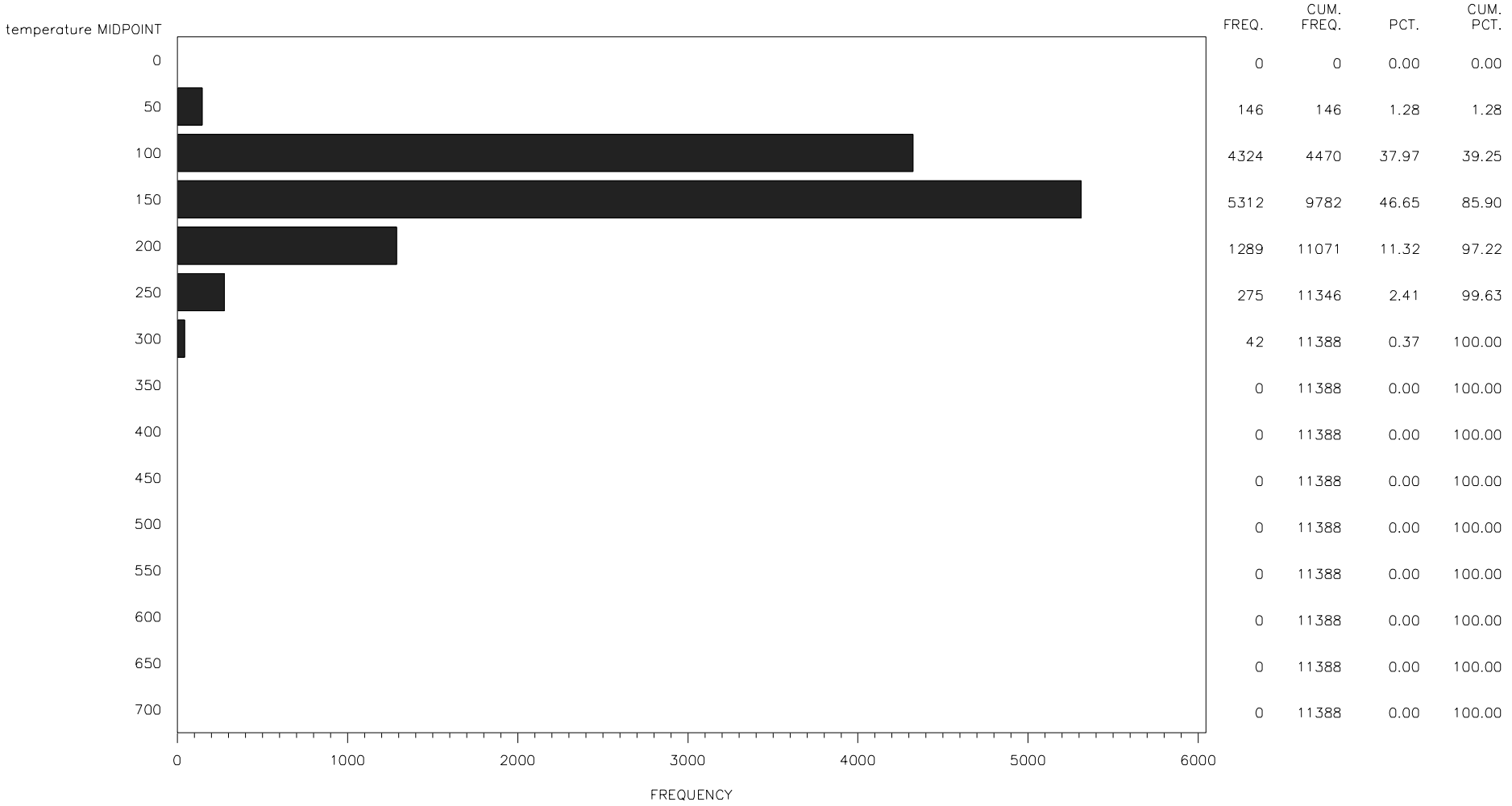
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	65	65	2.05	2.05
100	331	396	10.46	12.52
150	646	1042	20.42	32.93
200	1000	2042	31.61	64.54
250	642	2684	20.29	84.83
300	307	2991	9.70	94.53
350	124	3115	3.92	98.45
400	34	3149	1.07	99.53
450	14	3163	0.44	99.97
500	1	3164	0.03	100.00
550	0	3164	0.00	100.00
600	0	3164	0.00	100.00
650	0	3164	0.00	100.00
700	0	3164	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070508_1_Backhoe_PublicWorks



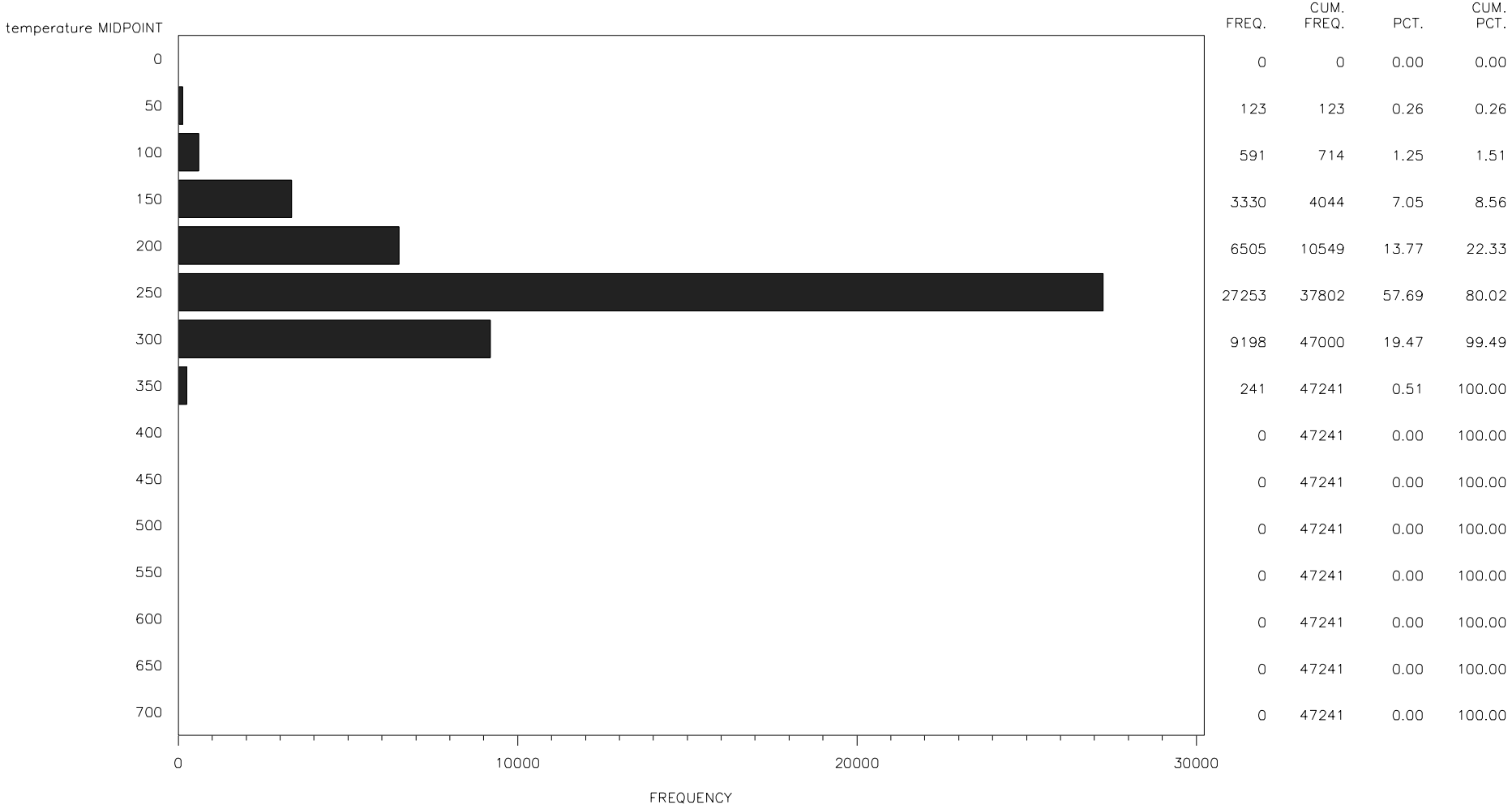
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	90	90	0.59	0.59
100	1715	1805	11.22	11.81
150	2722	4527	17.81	29.62
200	5523	10050	36.13	65.75
250	4194	14244	27.44	93.18
300	629	14873	4.11	97.30
350	341	15214	2.23	99.53
400	72	15286	0.47	100.00
450	0	15286	0.00	100.00
500	0	15286	0.00	100.00
550	0	15286	0.00	100.00
600	0	15286	0.00	100.00
650	0	15286	0.00	100.00
700	0	15286	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070515_1_Backhoe_KieferLandfill



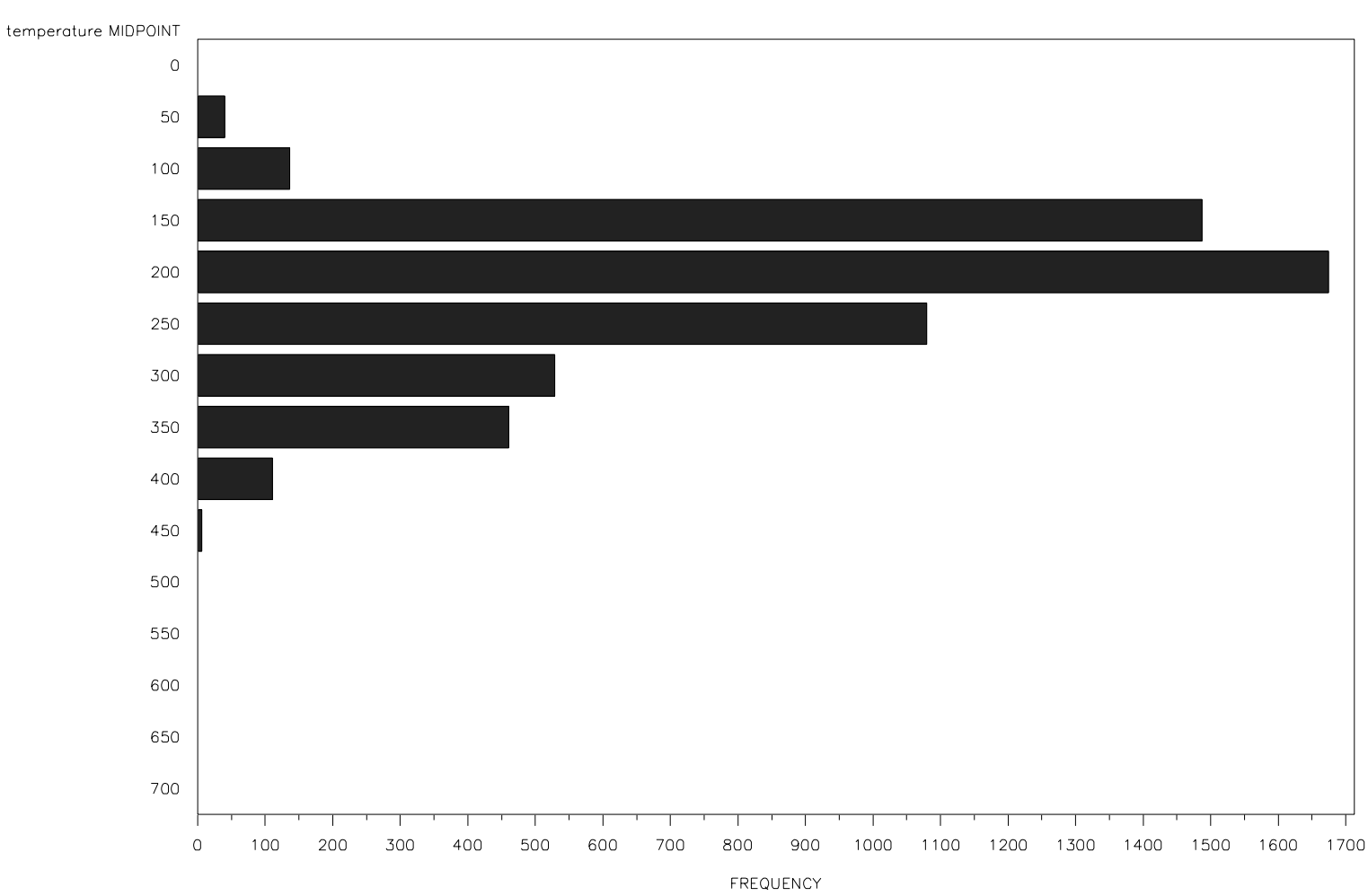
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	146	146	1.28	1.28
100	4324	4470	37.97	39.25
150	5312	9782	46.65	85.90
200	1289	11071	11.32	97.22
250	275	11346	2.41	99.63
300	42	11388	0.37	100.00
350	0	11388	0.00	100.00
400	0	11388	0.00	100.00
450	0	11388	0.00	100.00
500	0	11388	0.00	100.00
550	0	11388	0.00	100.00
600	0	11388	0.00	100.00
650	0	11388	0.00	100.00
700	0	11388	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070515_2_Grinder_KieferLandfill



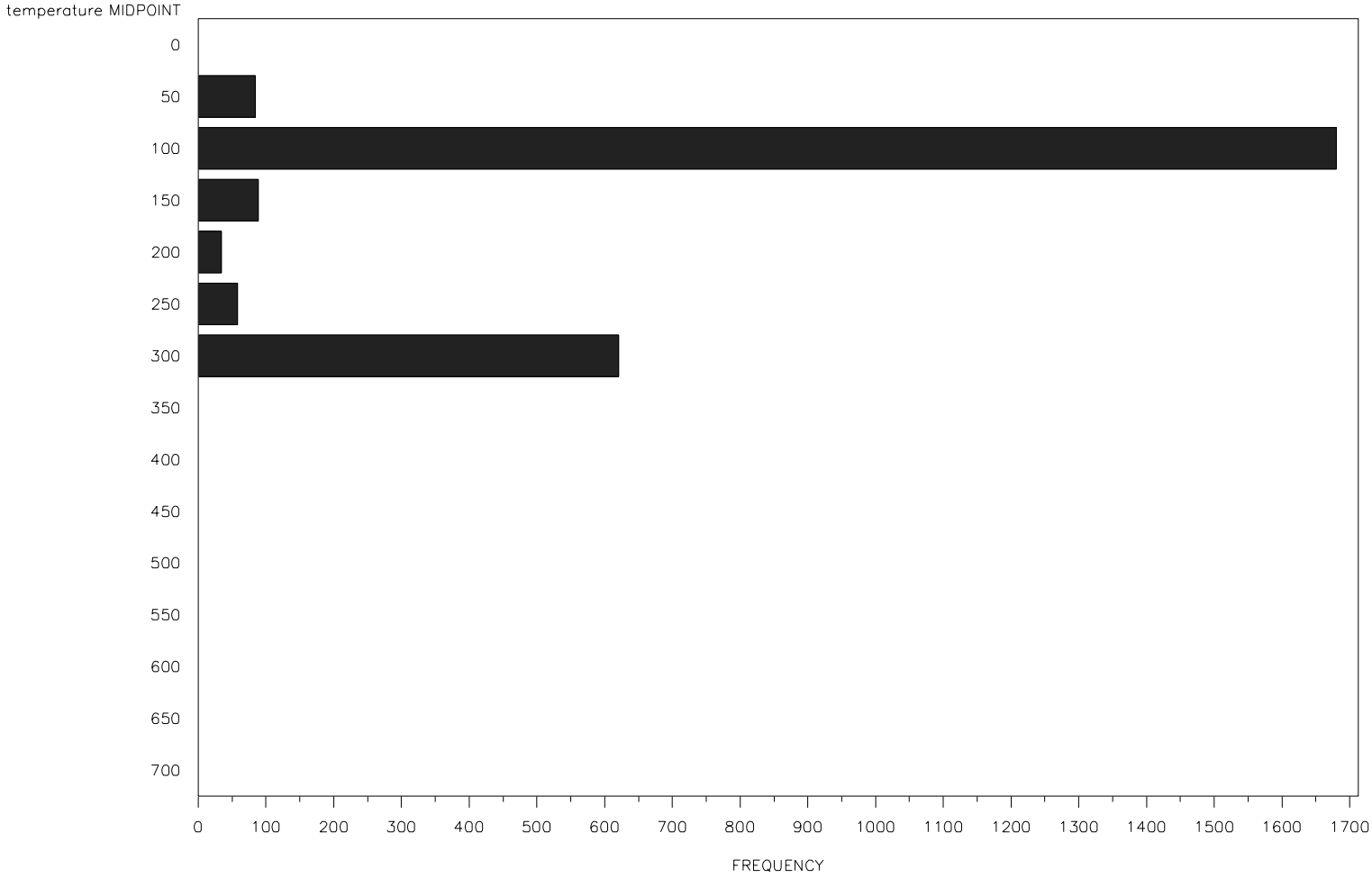
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	123	123	0.26	0.26
100	591	714	1.25	1.51
150	3330	4044	7.05	8.56
200	6505	10549	13.77	22.33
250	27253	37802	57.69	80.02
300	9198	47000	19.47	99.49
350	241	47241	0.51	100.00
400	0	47241	0.00	100.00
450	0	47241	0.00	100.00
500	0	47241	0.00	100.00
550	0	47241	0.00	100.00
600	0	47241	0.00	100.00
650	0	47241	0.00	100.00
700	0	47241	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070515_3_Loader_59thStYard



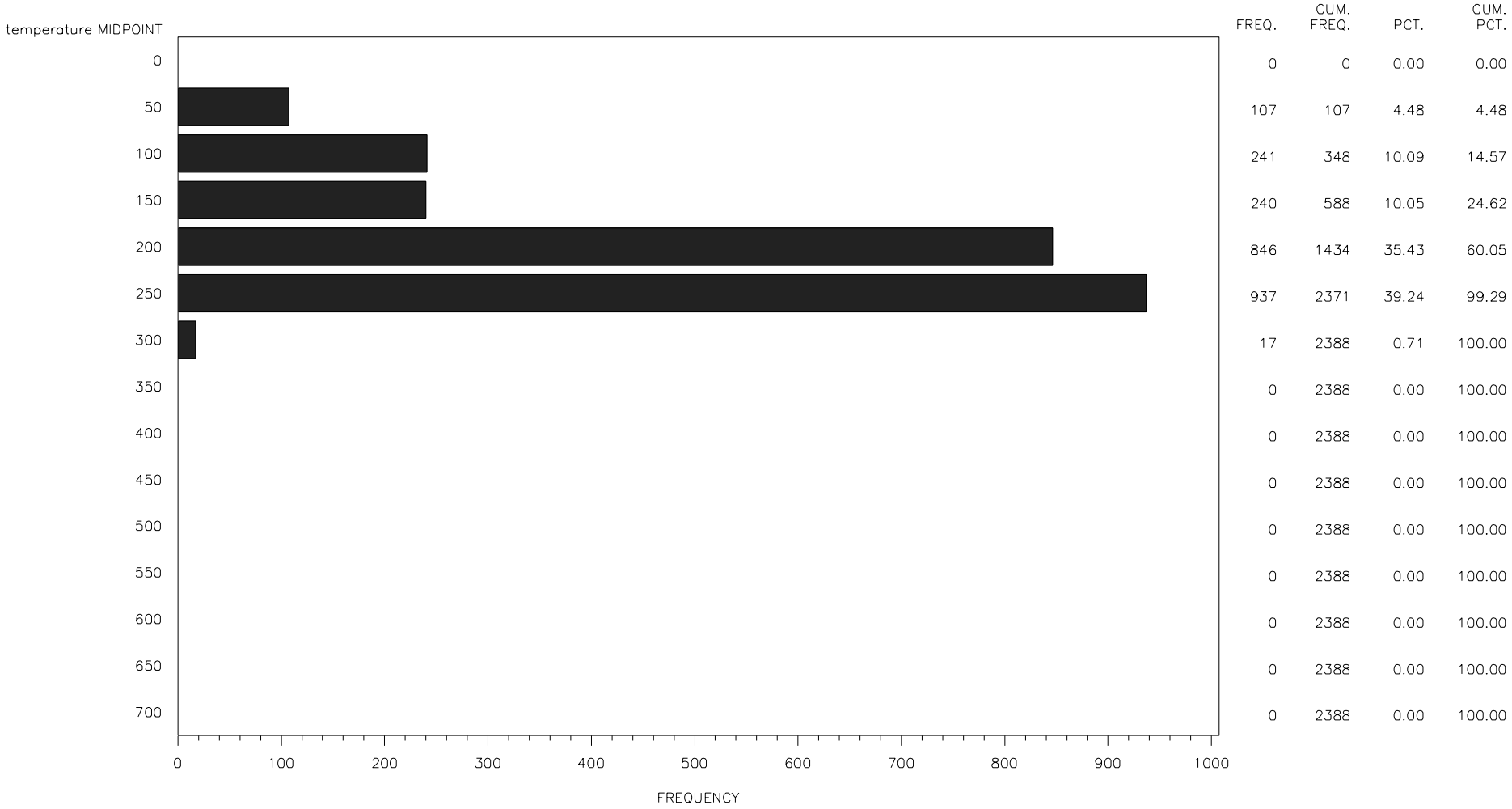
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	40	40	0.72	0.72
100	136	176	2.46	3.19
150	1487	1663	26.92	30.11
200	1674	3337	30.31	60.42
250	1079	4416	19.54	79.96
300	529	4945	9.58	89.53
350	461	5406	8.35	97.88
400	111	5517	2.01	99.89
450	6	5523	0.11	100.00
500	0	5523	0.00	100.00
550	0	5523	0.00	100.00
600	0	5523	0.00	100.00
650	0	5523	0.00	100.00
700	0	5523	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070516_1_Loader_WasteWaterTreatment



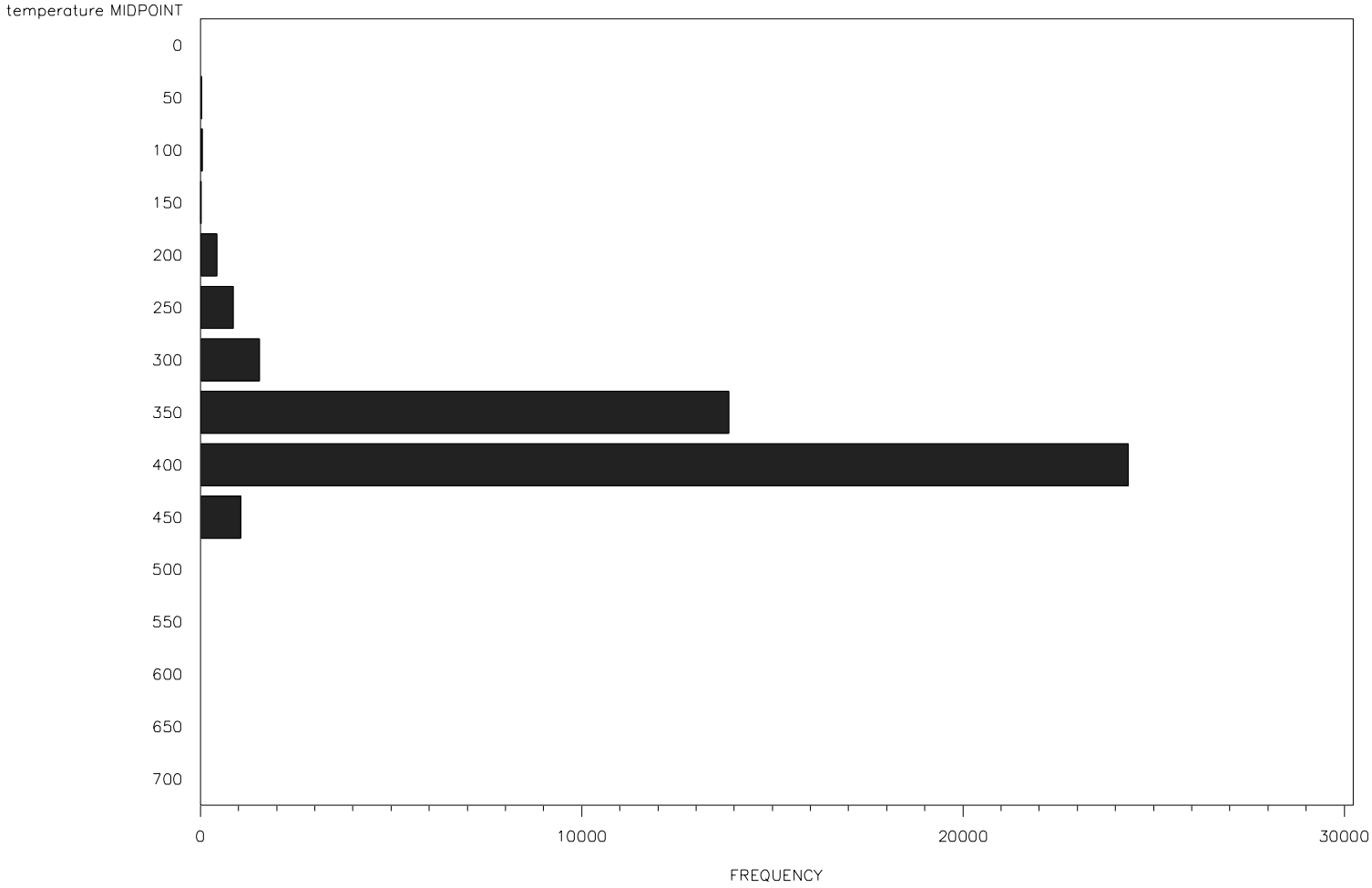
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	84	84	3.27	3.27
100	1680	1764	65.47	68.75
150	89	1853	3.47	72.21
200	34	1887	1.33	73.54
250	58	1945	2.26	75.80
300	621	2566	24.20	100.00
350	0	2566	0.00	100.00
400	0	2566	0.00	100.00
450	0	2566	0.00	100.00
500	0	2566	0.00	100.00
550	0	2566	0.00	100.00
600	0	2566	0.00	100.00
650	0	2566	0.00	100.00
700	0	2566	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070517_1_Backhoe_59thStYard



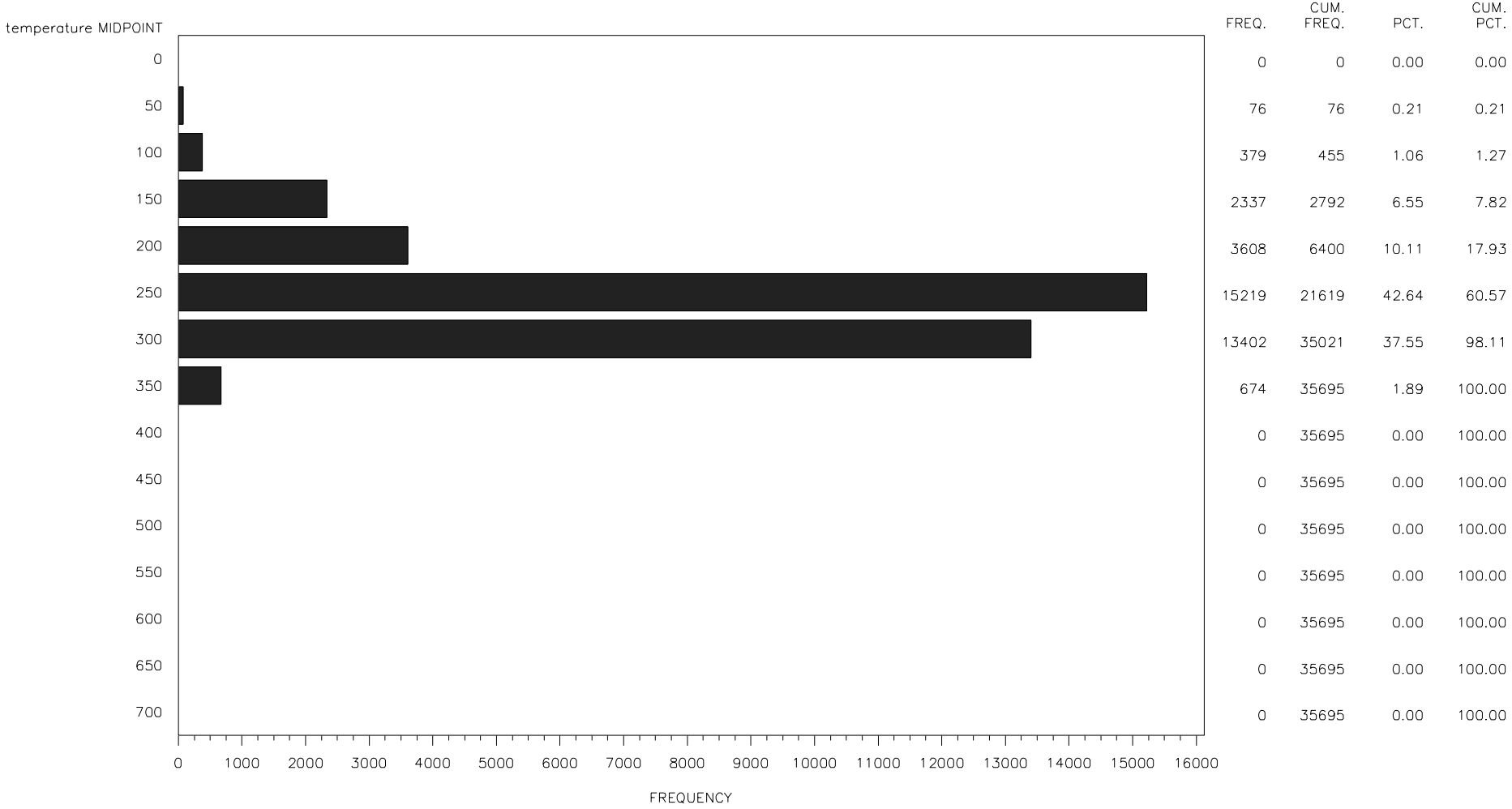
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	107	107	4.48	4.48
100	241	348	10.09	14.57
150	240	588	10.05	24.62
200	846	1434	35.43	60.05
250	937	2371	39.24	99.29
300	17	2388	0.71	100.00
350	0	2388	0.00	100.00
400	0	2388	0.00	100.00
450	0	2388	0.00	100.00
500	0	2388	0.00	100.00
550	0	2388	0.00	100.00
600	0	2388	0.00	100.00
650	0	2388	0.00	100.00
700	0	2388	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070521_1_Compactor_CommercialConstruction



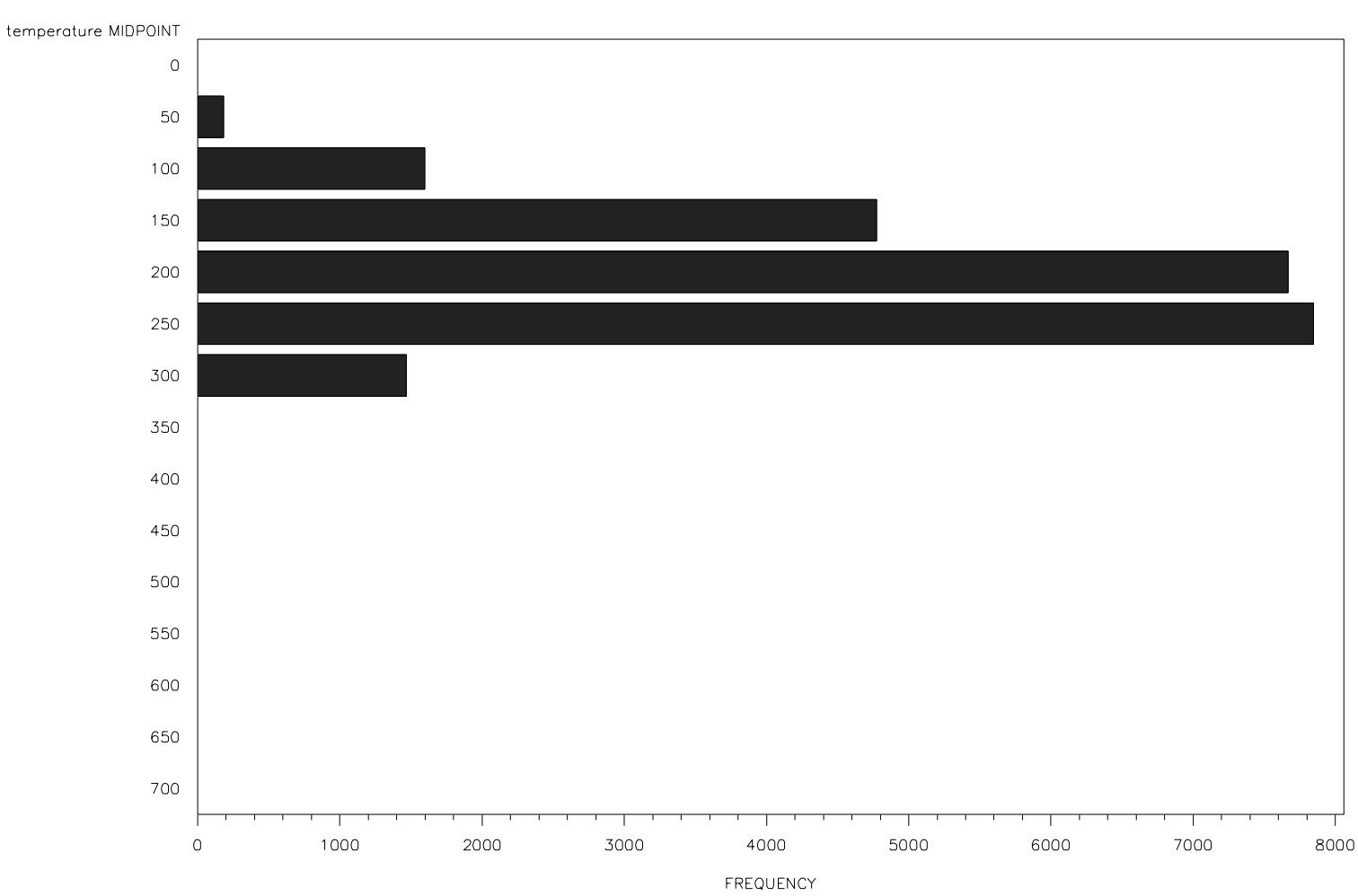
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	33	33	0.08	0.08
100	52	85	0.12	0.20
150	20	105	0.05	0.25
200	436	541	1.03	1.28
250	860	1401	2.04	3.32
300	1547	2948	3.67	6.99
350	13863	16811	32.85	39.83
400	24337	41148	57.67	97.50
450	1055	42203	2.50	100.00
500	0	42203	0.00	100.00
550	0	42203	0.00	100.00
600	0	42203	0.00	100.00
650	0	42203	0.00	100.00
700	0	42203	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070522_1_Screener_KieferLandfill



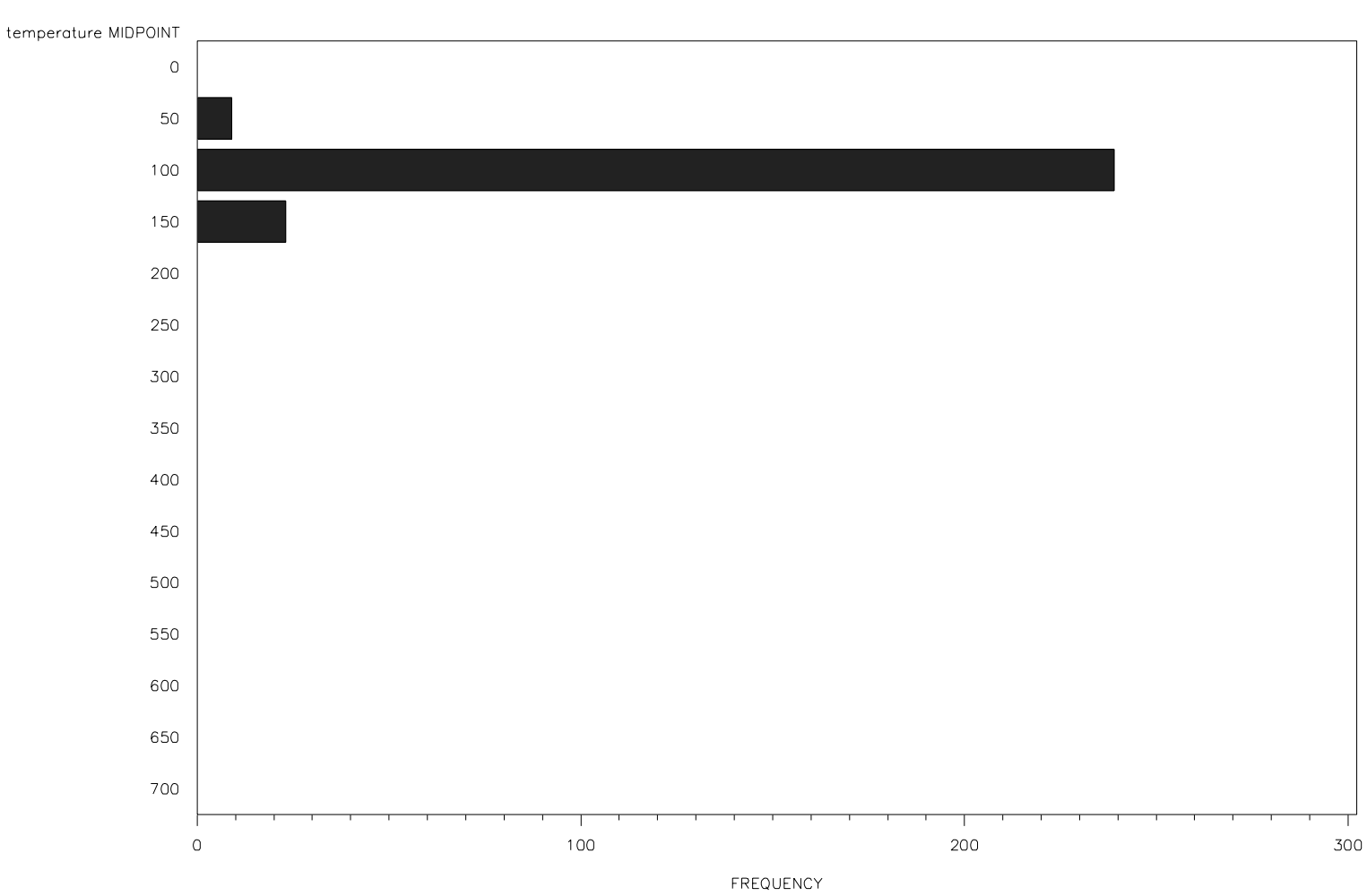
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	76	76	0.21	0.21
100	379	455	1.06	1.27
150	2337	2792	6.55	7.82
200	3608	6400	10.11	17.93
250	15219	21619	42.64	60.57
300	13402	35021	37.55	98.11
350	674	35695	1.89	100.00
400	0	35695	0.00	100.00
450	0	35695	0.00	100.00
500	0	35695	0.00	100.00
550	0	35695	0.00	100.00
600	0	35695	0.00	100.00
650	0	35695	0.00	100.00
700	0	35695	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070522_2_Backhoe_59thStYard



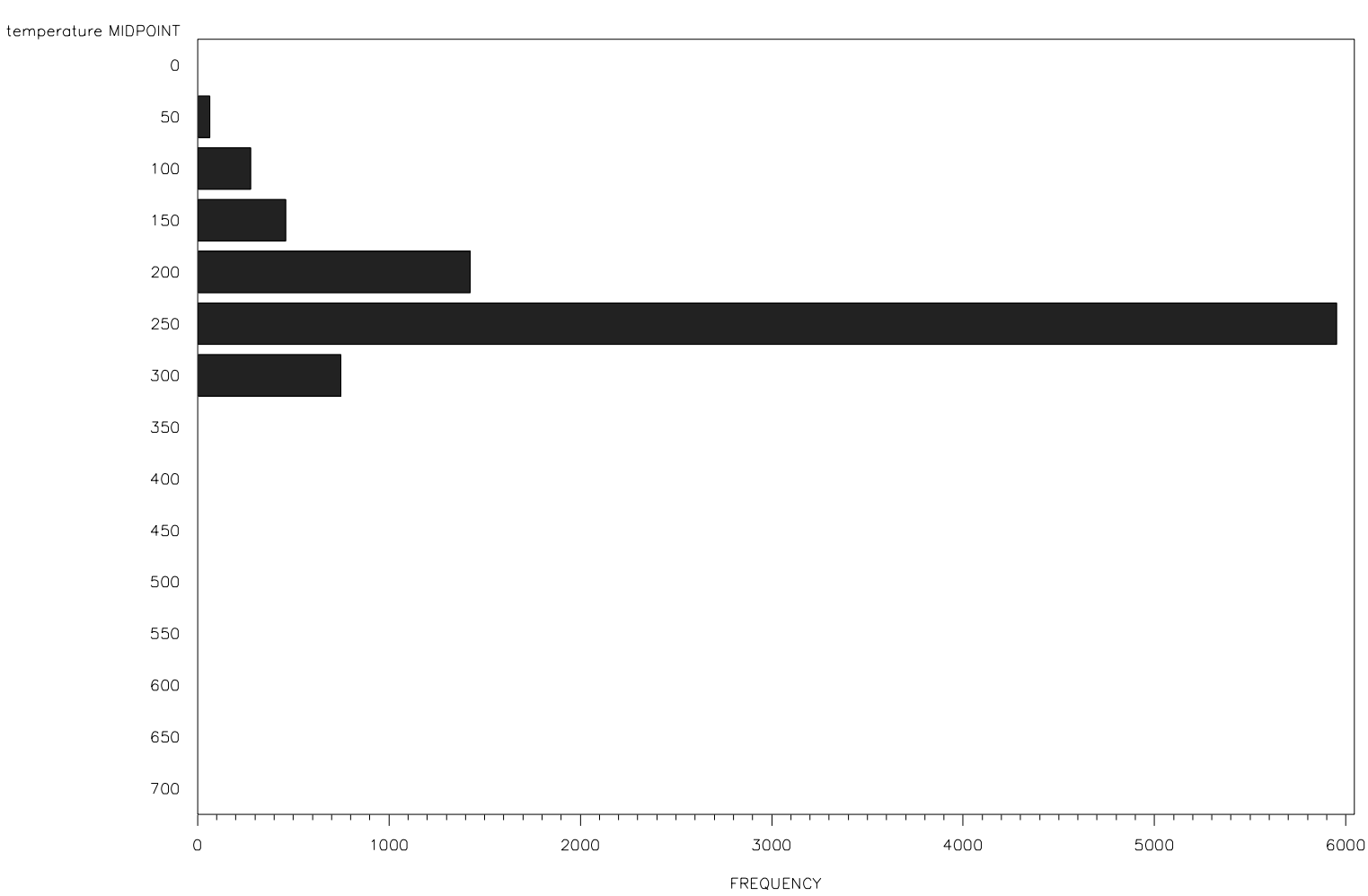
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	182	182	0.77	0.77
100	1595	1777	6.78	7.55
150	4772	6549	20.28	27.83
200	7666	14215	32.58	60.41
250	7847	22062	33.35	93.76
300	1469	23531	6.24	100.00
350	0	23531	0.00	100.00
400	0	23531	0.00	100.00
450	0	23531	0.00	100.00
500	0	23531	0.00	100.00
550	0	23531	0.00	100.00
600	0	23531	0.00	100.00
650	0	23531	0.00	100.00
700	0	23531	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070523_1_Loader_ResidentialConstruction



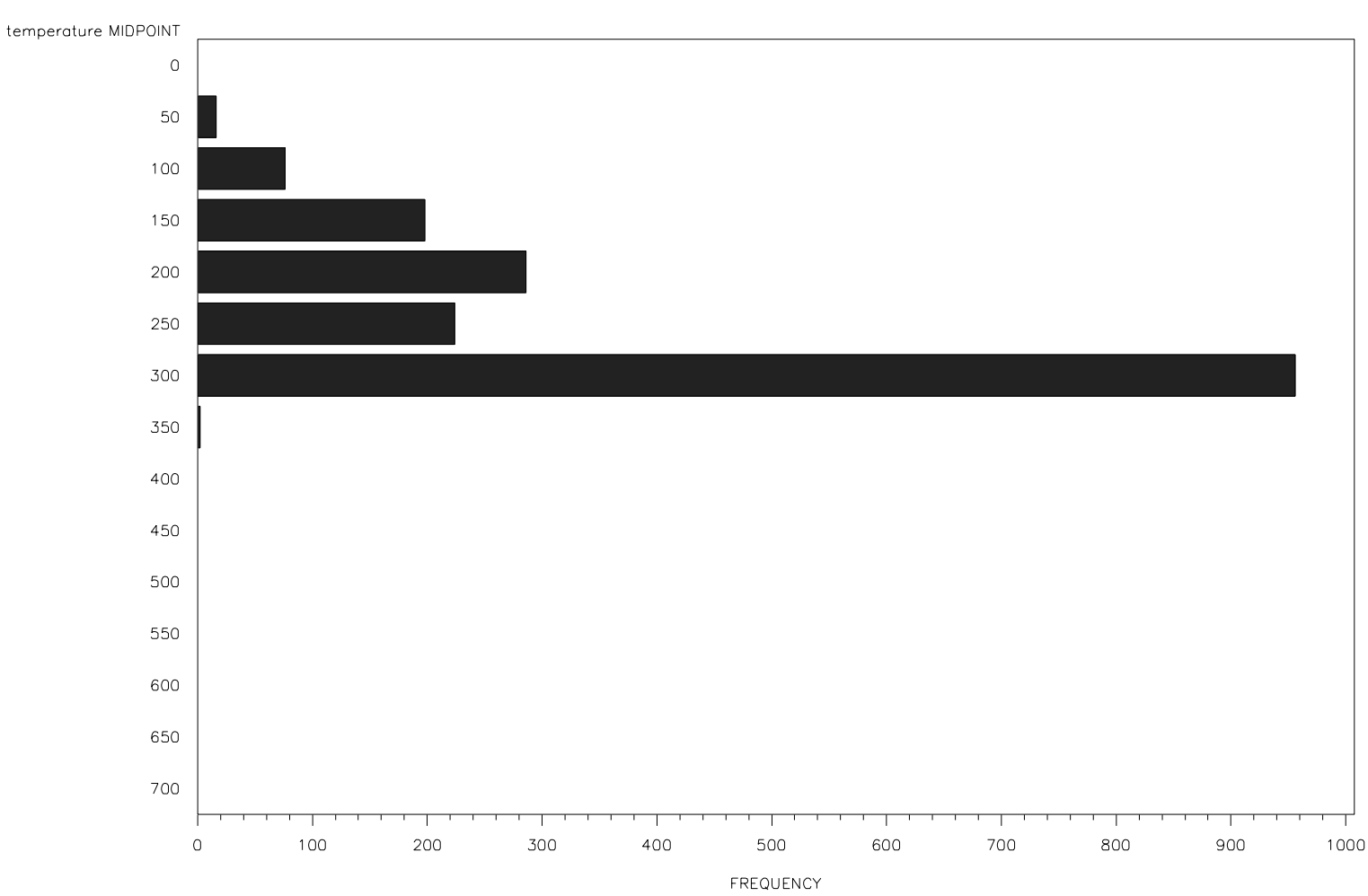
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	9	9	3.32	3.32
100	239	248	88.19	91.51
150	23	271	8.49	100.00
200	0	271	0.00	100.00
250	0	271	0.00	100.00
300	0	271	0.00	100.00
350	0	271	0.00	100.00
400	0	271	0.00	100.00
450	0	271	0.00	100.00
500	0	271	0.00	100.00
550	0	271	0.00	100.00
600	0	271	0.00	100.00
650	0	271	0.00	100.00
700	0	271	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070524_1_Backhoe_WasteWaterTreatment



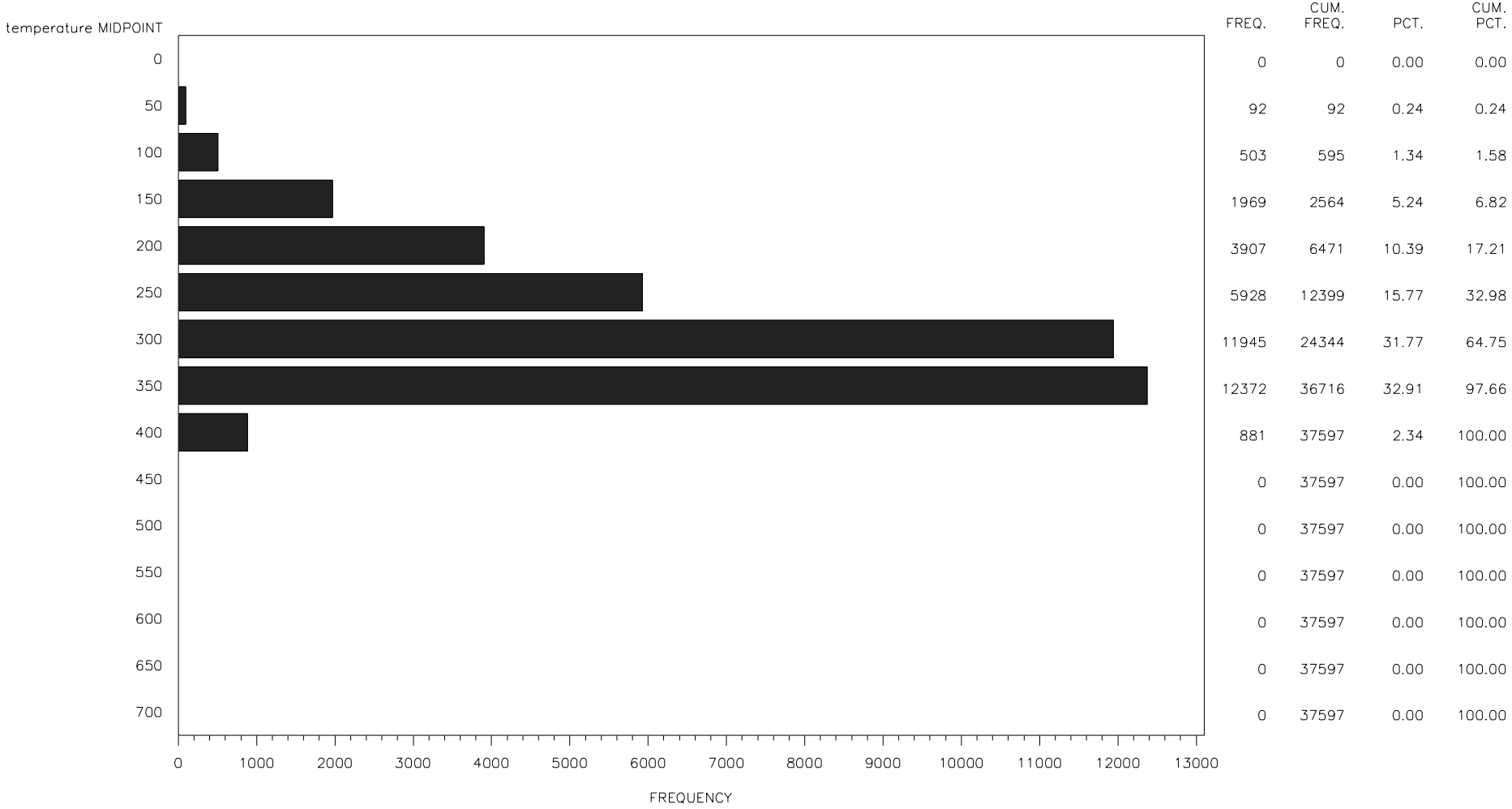
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	64	64	0.72	0.72
100	278	342	3.12	3.83
150	459	801	5.14	8.98
200	1424	2225	15.96	24.93
250	5952	8177	66.70	91.63
300	747	8924	8.37	100.00
350	0	8924	0.00	100.00
400	0	8924	0.00	100.00
450	0	8924	0.00	100.00
500	0	8924	0.00	100.00
550	0	8924	0.00	100.00
600	0	8924	0.00	100.00
650	0	8924	0.00	100.00
700	0	8924	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070526_1_Loader_ResidentialConstruction



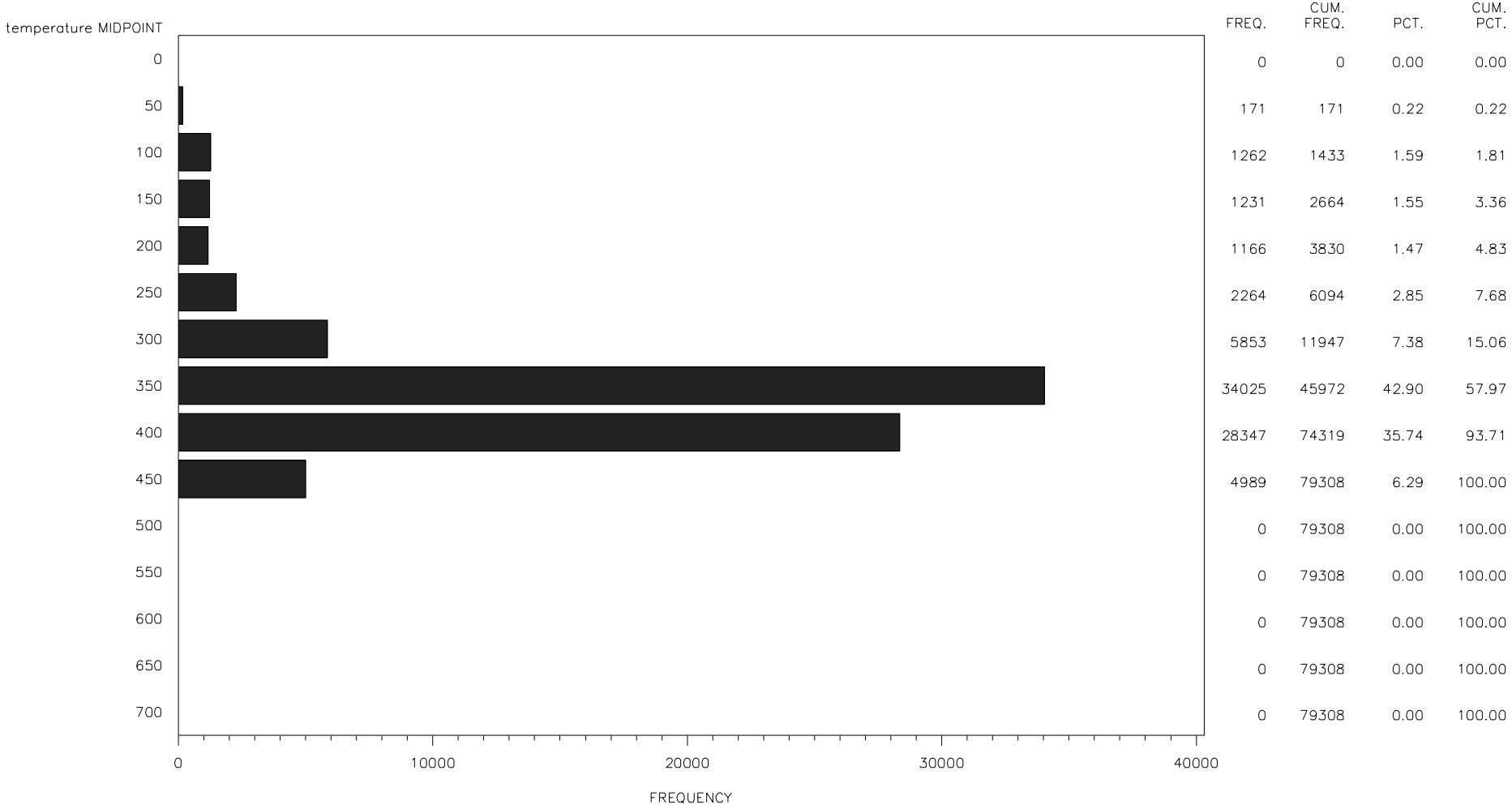
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	16	16	0.91	0.91
100	76	92	4.32	5.23
150	198	290	11.26	16.50
200	286	576	16.27	32.76
250	224	800	12.74	45.51
300	956	1756	54.38	99.89
350	2	1758	0.11	100.00
400	0	1758	0.00	100.00
450	0	1758	0.00	100.00
500	0	1758	0.00	100.00
550	0	1758	0.00	100.00
600	0	1758	0.00	100.00
650	0	1758	0.00	100.00
700	0	1758	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070529_1_Grinder_Landfill



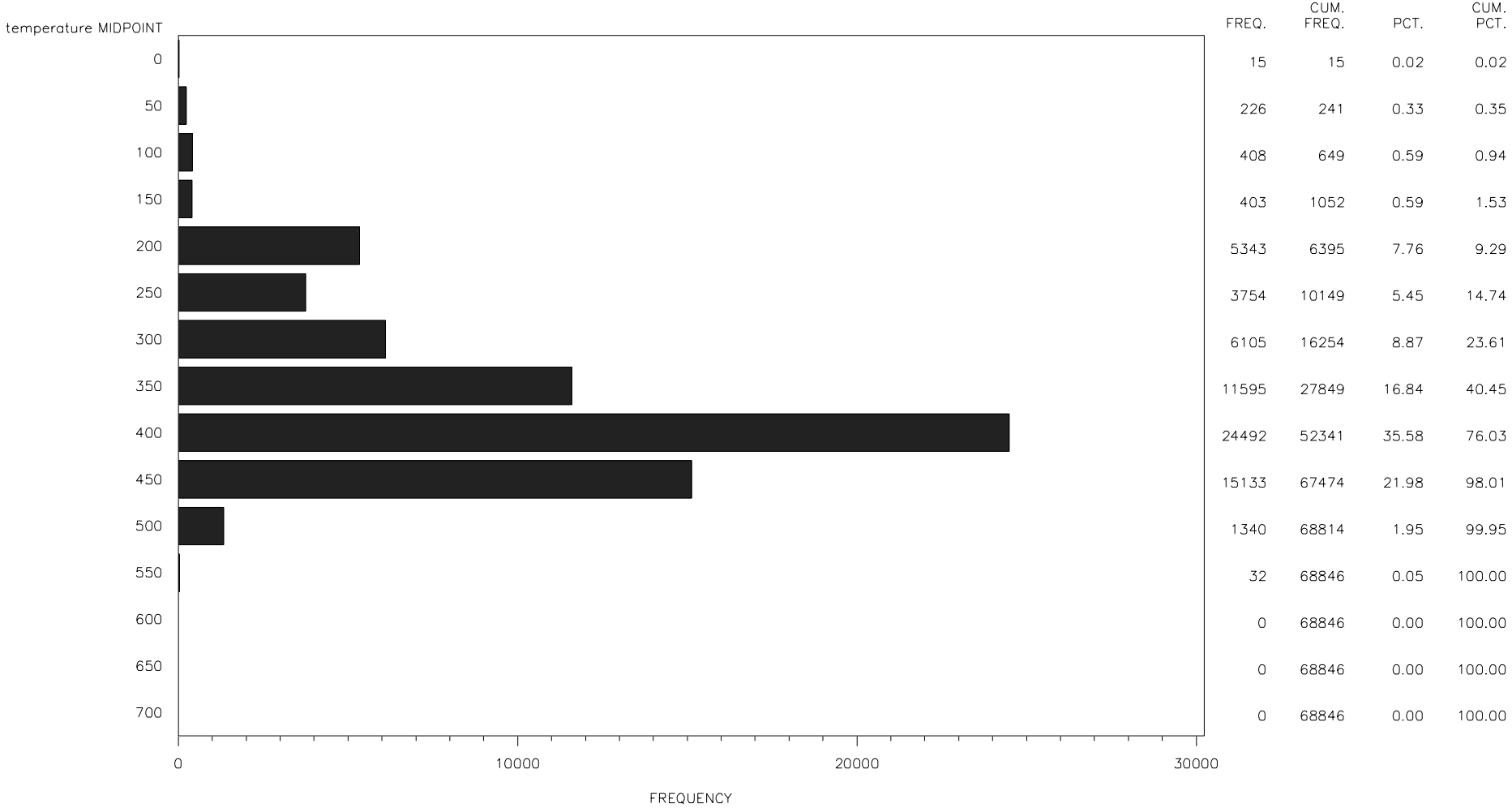
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	92	92	0.24	0.24
100	503	595	1.34	1.58
150	1969	2564	5.24	6.82
200	3907	6471	10.39	17.21
250	5928	12399	15.77	32.98
300	11945	24344	31.77	64.75
350	12372	36716	32.91	97.66
400	881	37597	2.34	100.00
450	0	37597	0.00	100.00
500	0	37597	0.00	100.00
550	0	37597	0.00	100.00
600	0	37597	0.00	100.00
650	0	37597	0.00	100.00
700	0	37597	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070529_2_Compactor_KieferLandfill



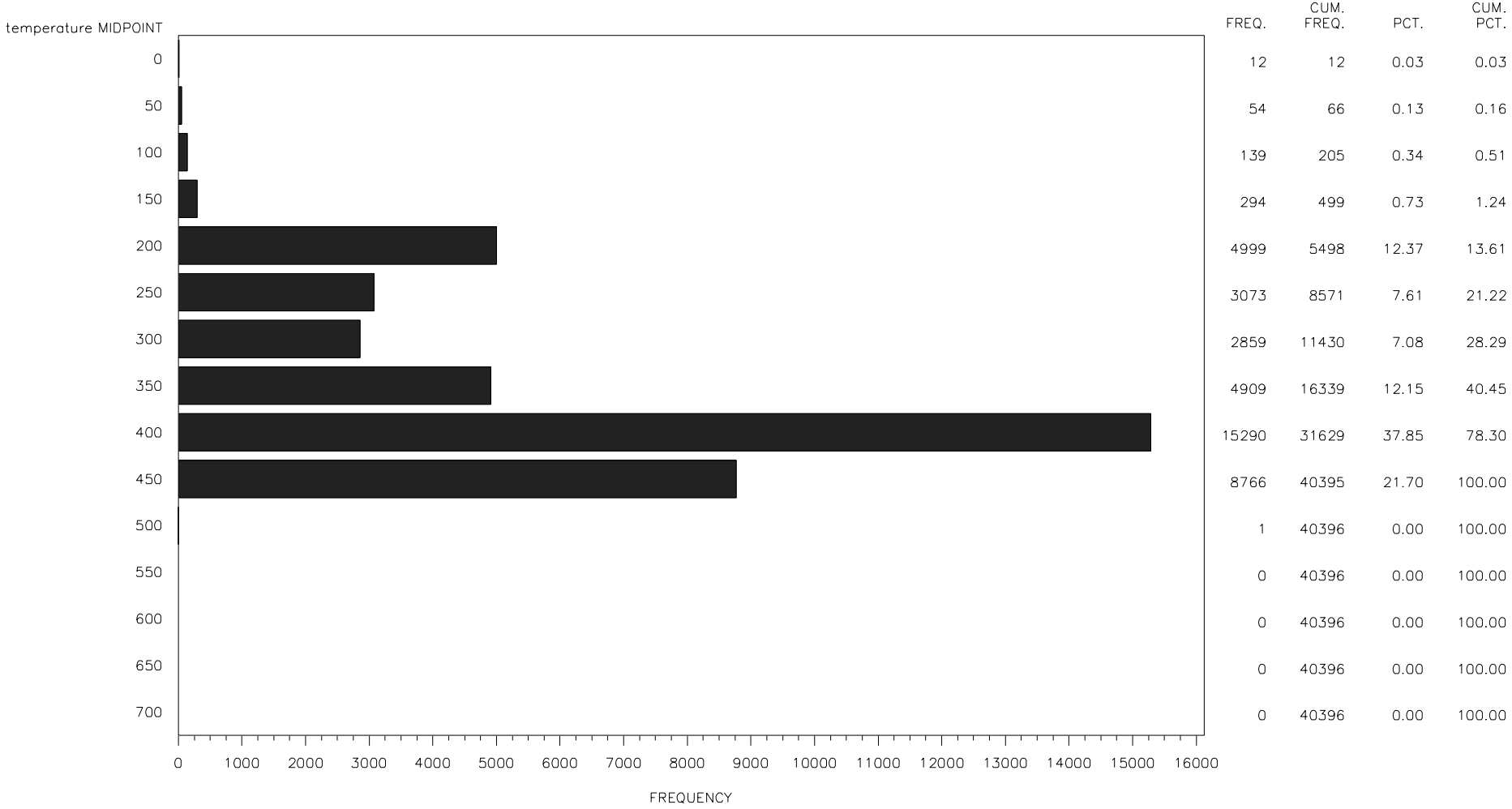
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	171	171	0.22	0.22
100	1262	1433	1.59	1.81
150	1231	2664	1.55	3.36
200	1166	3830	1.47	4.83
250	2264	6094	2.85	7.68
300	5853	11947	7.38	15.06
350	34025	45972	42.90	57.97
400	28347	74319	35.74	93.71
450	4989	79308	6.29	100.00
500	0	79308	0.00	100.00
550	0	79308	0.00	100.00
600	0	79308	0.00	100.00
650	0	79308	0.00	100.00
700	0	79308	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070530_1_Grader_KieferLandfill



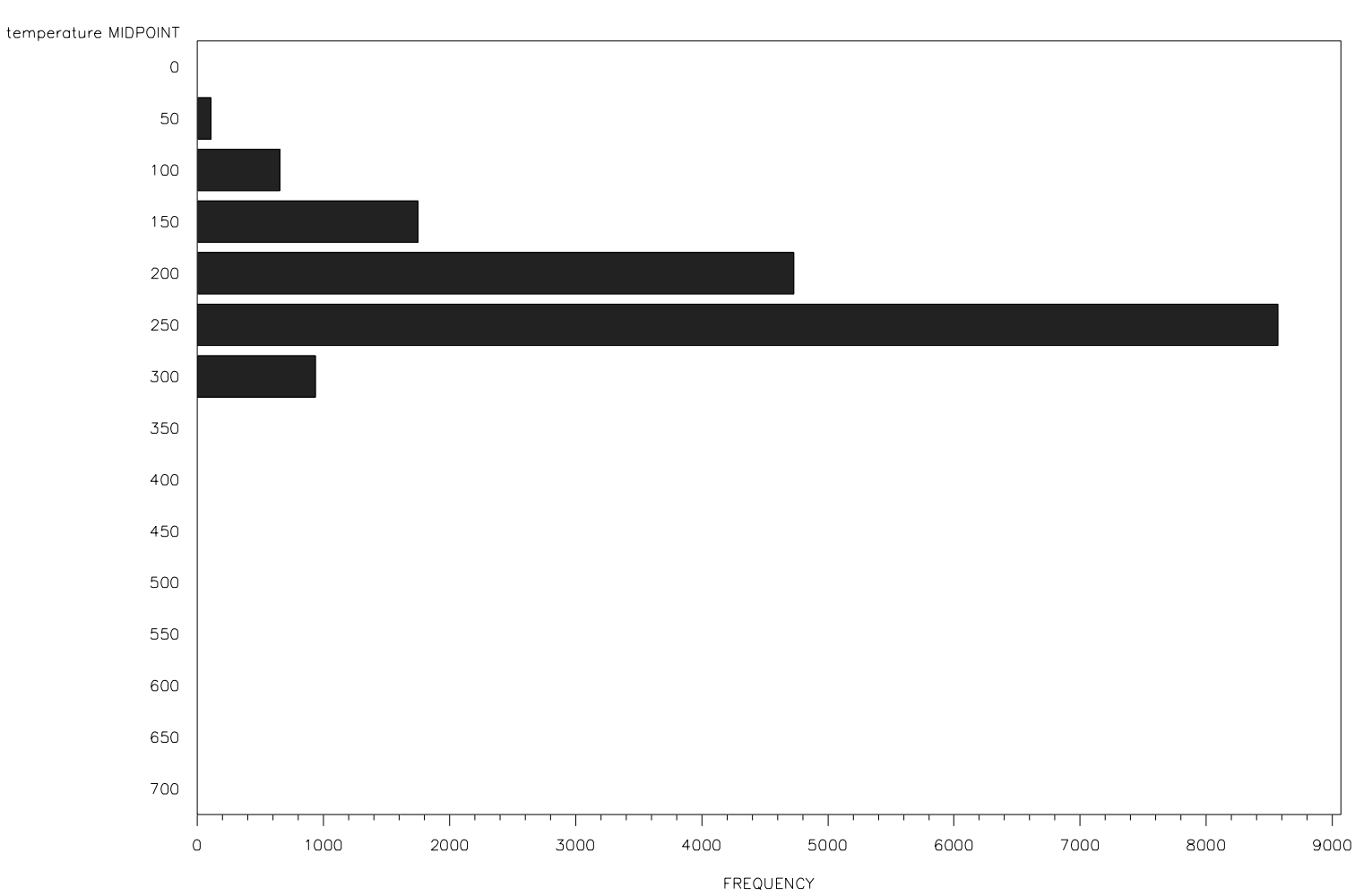
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	15	15	0.02	0.02
50	226	241	0.33	0.35
100	408	649	0.59	0.94
150	403	1052	0.59	1.53
200	5343	6395	7.76	9.29
250	3754	10149	5.45	14.74
300	6105	16254	8.87	23.61
350	11595	27849	16.84	40.45
400	24492	52341	35.58	76.03
450	15133	67474	21.98	98.01
500	1340	68814	1.95	99.95
550	32	68846	0.05	100.00
600	0	68846	0.00	100.00
650	0	68846	0.00	100.00
700	0	68846	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070530_2_Loader_CommercialConstruction



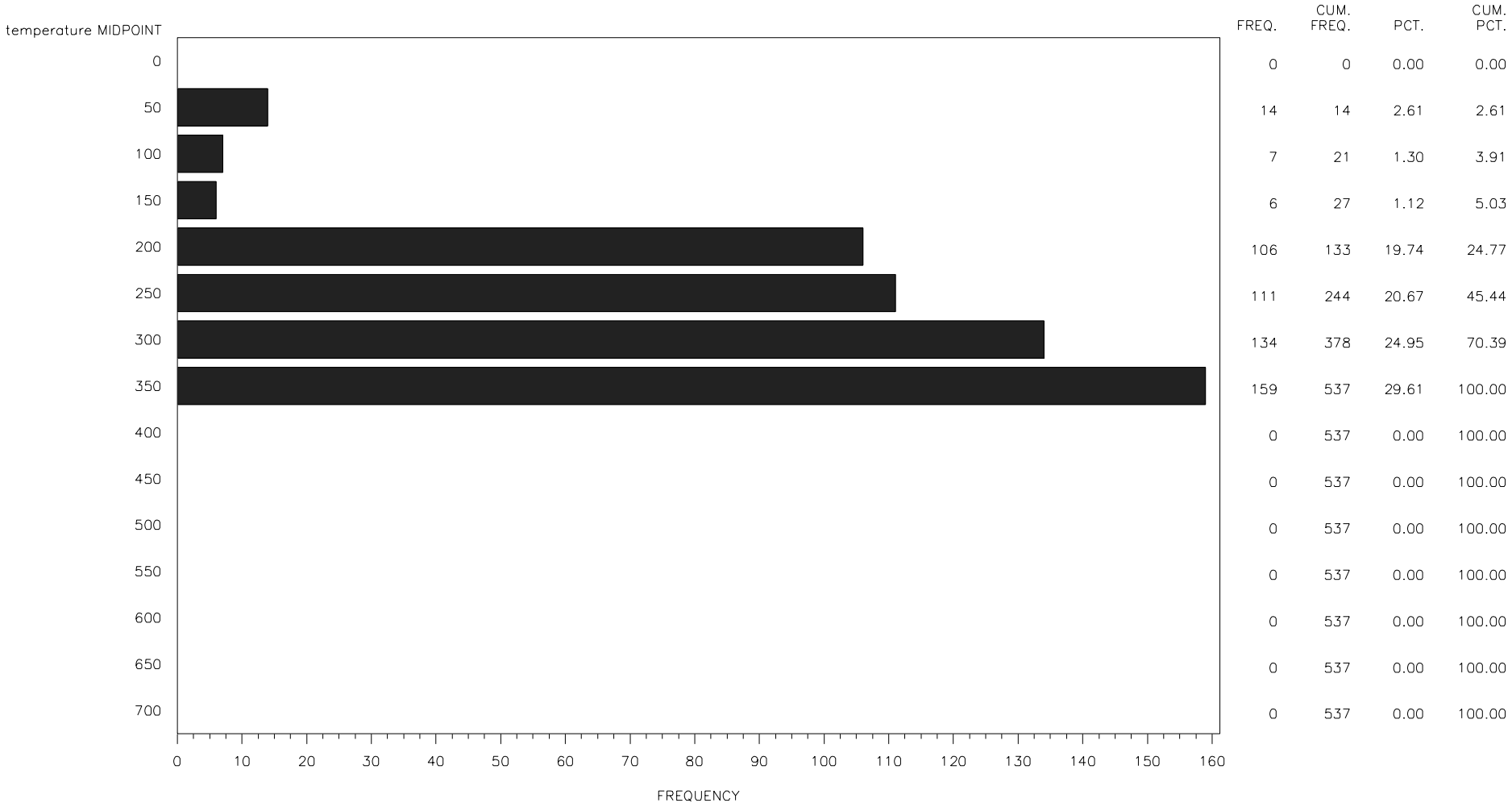
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	12	12	0.03	0.03
50	54	66	0.13	0.16
100	139	205	0.34	0.51
150	294	499	0.73	1.24
200	4999	5498	12.37	13.61
250	3073	8571	7.61	21.22
300	2859	11430	7.08	28.29
350	4909	16339	12.15	40.45
400	15290	31629	37.85	78.30
450	8766	40395	21.70	100.00
500	1	40396	0.00	100.00
550	0	40396	0.00	100.00
600	0	40396	0.00	100.00
650	0	40396	0.00	100.00
700	0	40396	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070531_1_Backhoe_CommercialConstruction



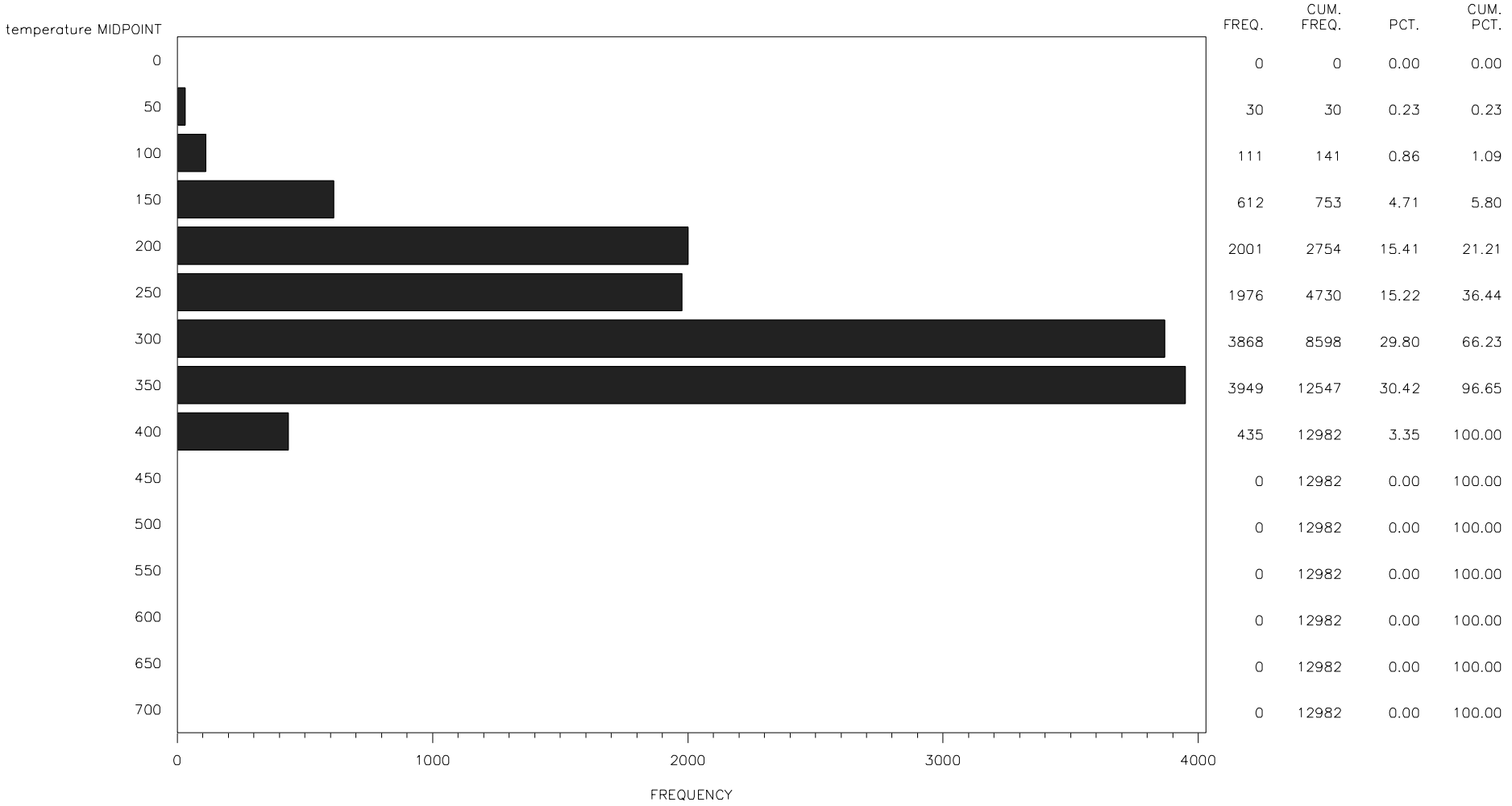
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	108	108	0.64	0.64
100	655	763	3.91	4.56
150	1752	2515	10.46	15.01
200	4728	7243	28.23	43.24
250	8568	15811	51.15	94.39
300	939	16750	5.61	100.00
350	0	16750	0.00	100.00
400	0	16750	0.00	100.00
450	0	16750	0.00	100.00
500	0	16750	0.00	100.00
550	0	16750	0.00	100.00
600	0	16750	0.00	100.00
650	0	16750	0.00	100.00
700	0	16750	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070601_1_Backhoe_WasteWaterTreatment



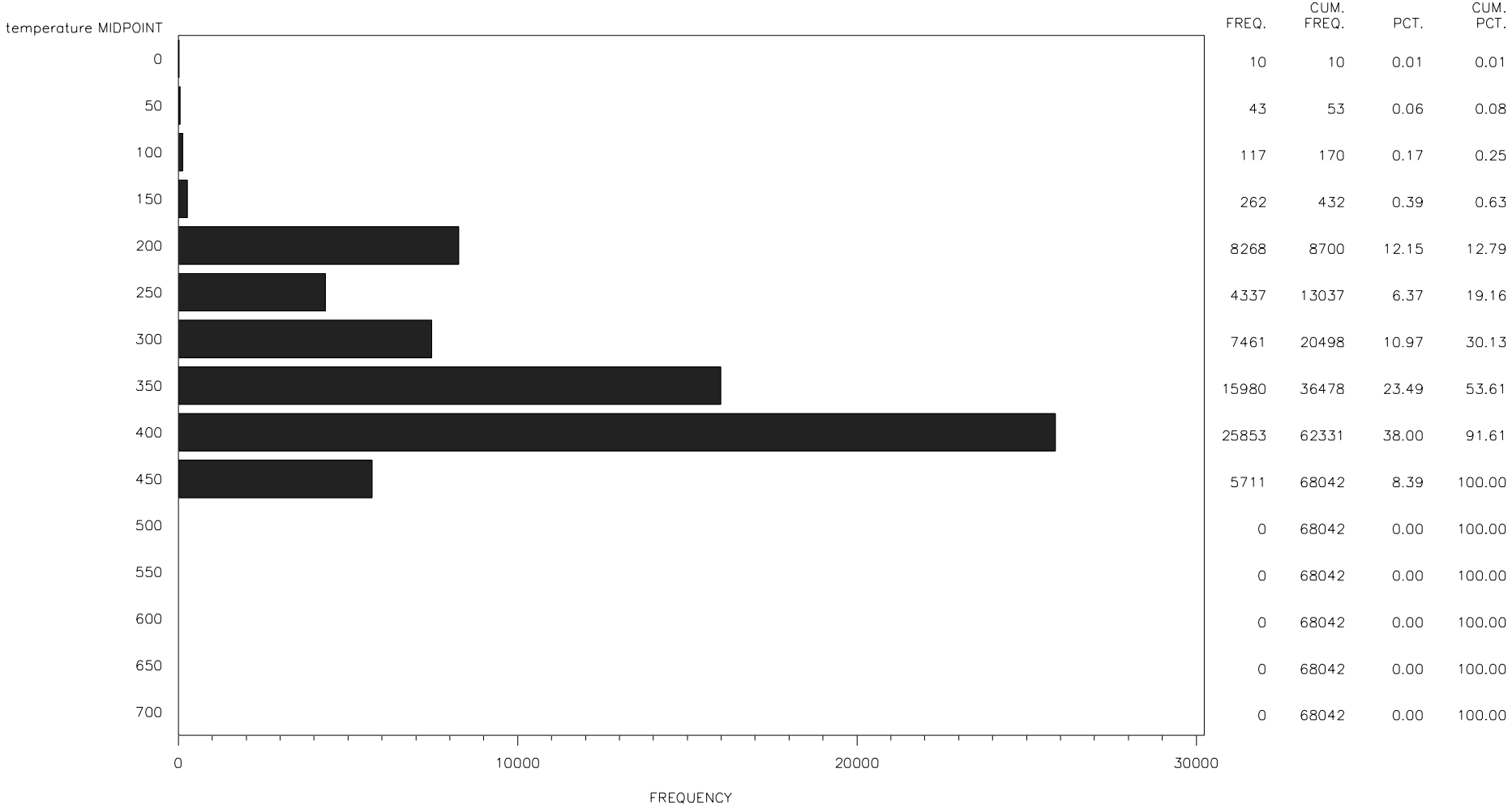
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	14	14	2.61	2.61
100	7	21	1.30	3.91
150	6	27	1.12	5.03
200	106	133	19.74	24.77
250	111	244	20.67	45.44
300	134	378	24.95	70.39
350	159	537	29.61	100.00
400	0	537	0.00	100.00
450	0	537	0.00	100.00
500	0	537	0.00	100.00
550	0	537	0.00	100.00
600	0	537	0.00	100.00
650	0	537	0.00	100.00
700	0	537	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070602_1_Backhoe_PublicWorks



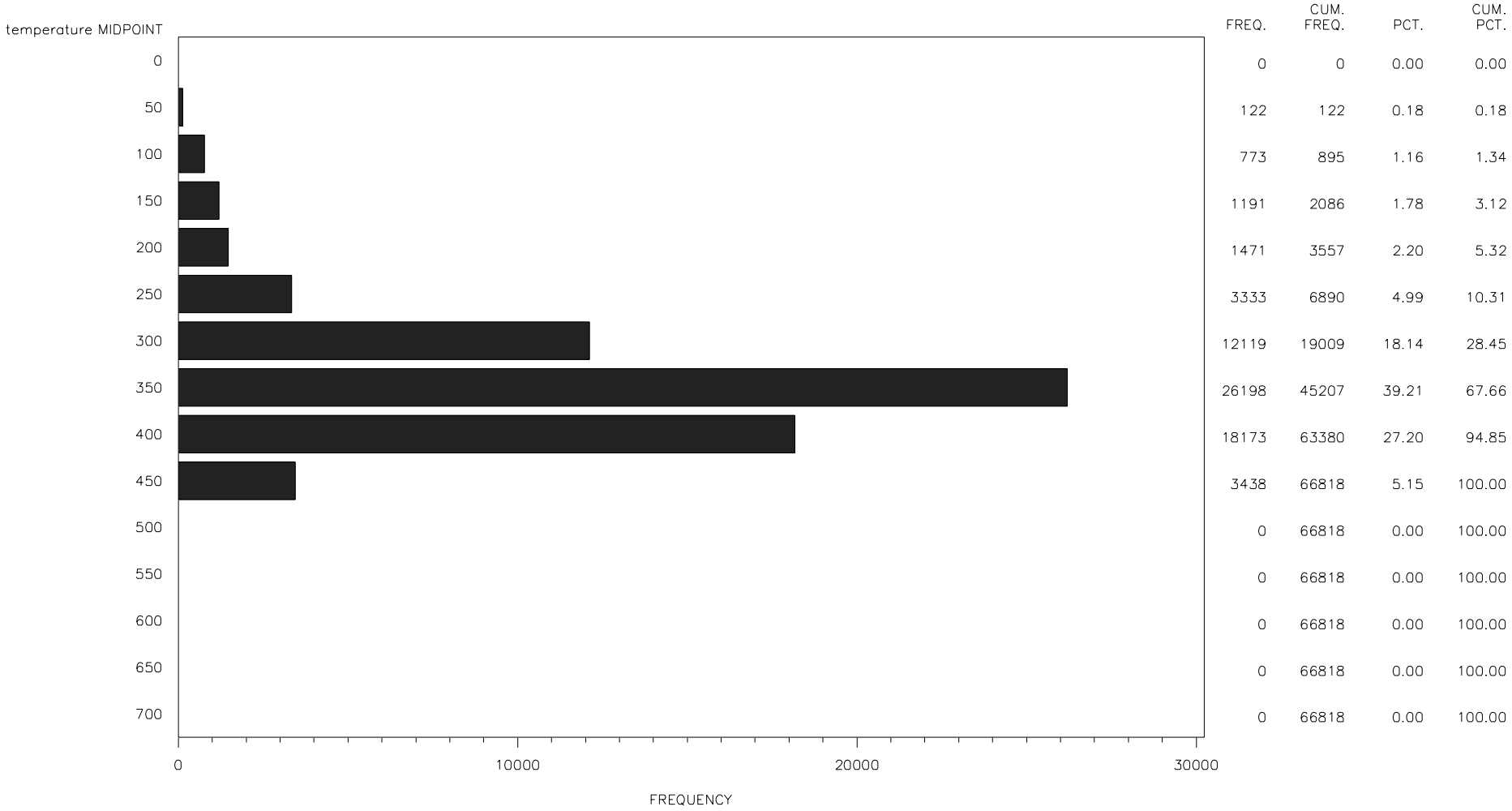
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	30	30	0.23	0.23
100	111	141	0.86	1.09
150	612	753	4.71	5.80
200	2001	2754	15.41	21.21
250	1976	4730	15.22	36.44
300	3868	8598	29.80	66.23
350	3949	12547	30.42	96.65
400	435	12982	3.35	100.00
450	0	12982	0.00	100.00
500	0	12982	0.00	100.00
550	0	12982	0.00	100.00
600	0	12982	0.00	100.00
650	0	12982	0.00	100.00
700	0	12982	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070602__2__Loader__KieferLandfill



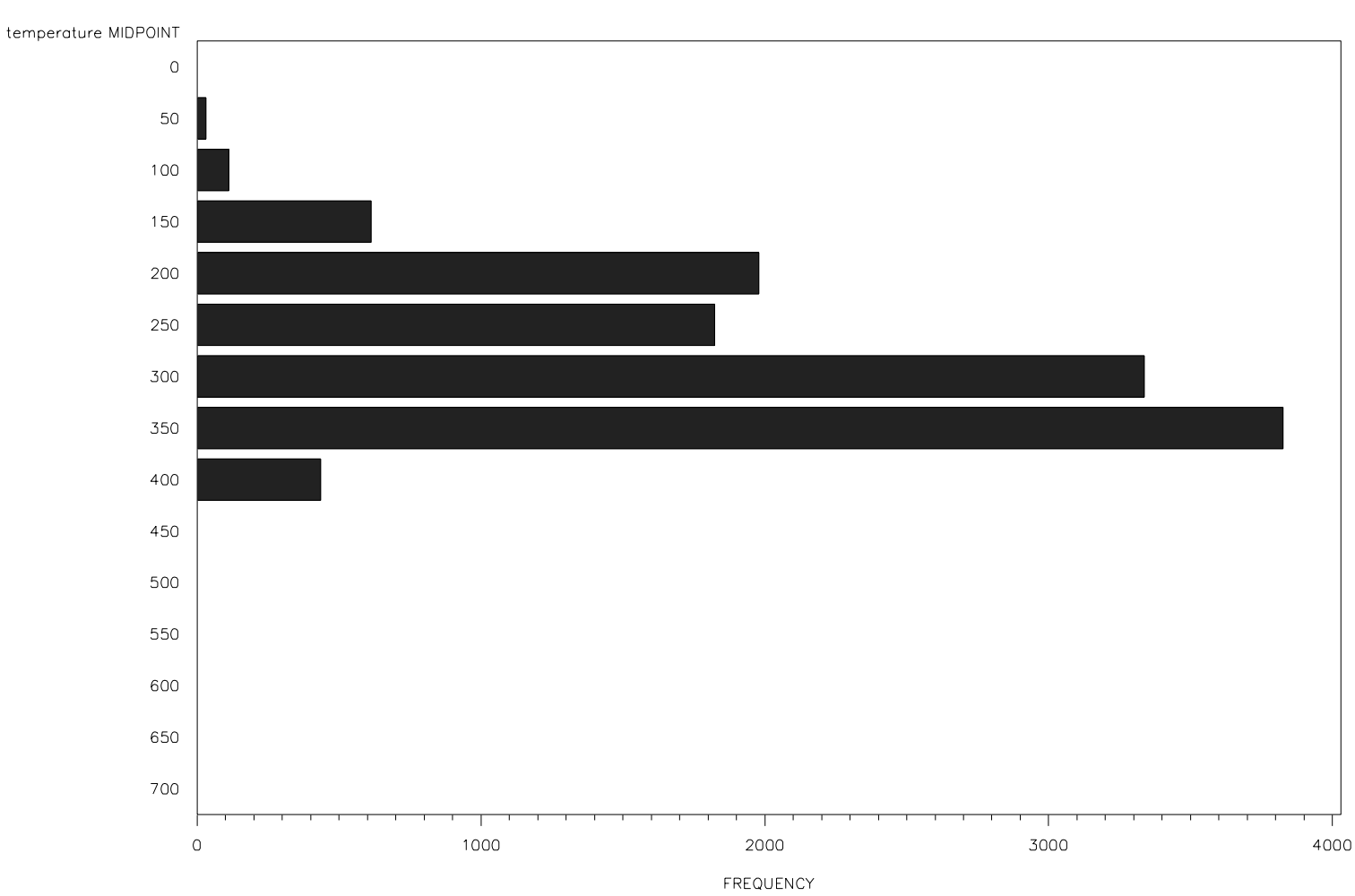
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	10	10	0.01	0.01
50	43	53	0.06	0.08
100	117	170	0.17	0.25
150	262	432	0.39	0.63
200	8268	8700	12.15	12.79
250	4337	13037	6.37	19.16
300	7461	20498	10.97	30.13
350	15980	36478	23.49	53.61
400	25853	62331	38.00	91.61
450	5711	68042	8.39	100.00
500	0	68042	0.00	100.00
550	0	68042	0.00	100.00
600	0	68042	0.00	100.00
650	0	68042	0.00	100.00
700	0	68042	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070604_1_Dozer_KieferLandfill



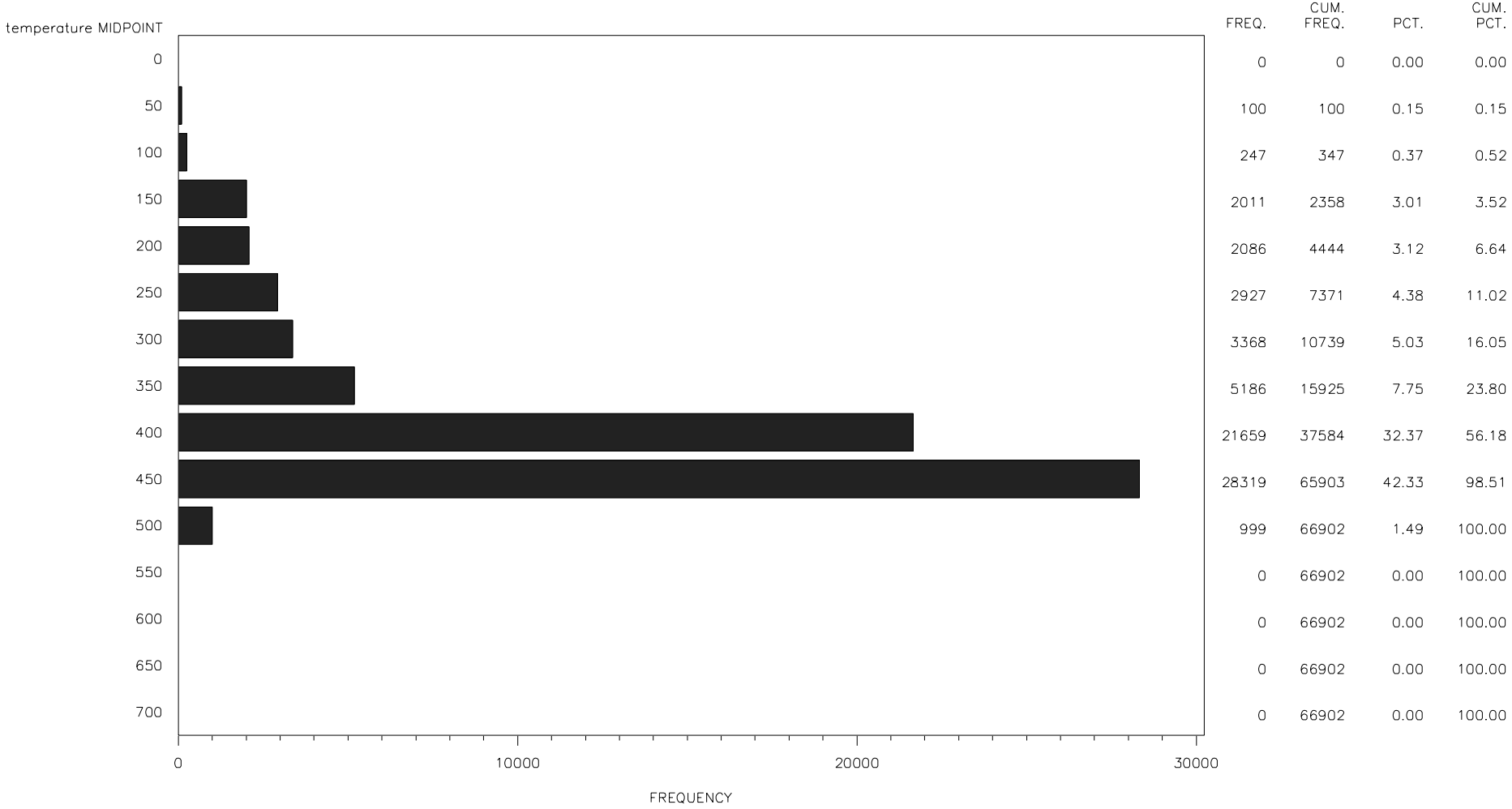
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	122	122	0.18	0.18
100	773	895	1.16	1.34
150	1191	2086	1.78	3.12
200	1471	3557	2.20	5.32
250	3333	6890	4.99	10.31
300	12119	19009	18.14	28.45
350	26198	45207	39.21	67.66
400	18173	63380	27.20	94.85
450	3438	66818	5.15	100.00
500	0	66818	0.00	100.00
550	0	66818	0.00	100.00
600	0	66818	0.00	100.00
650	0	66818	0.00	100.00
700	0	66818	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070605_1_Screener_Landfill



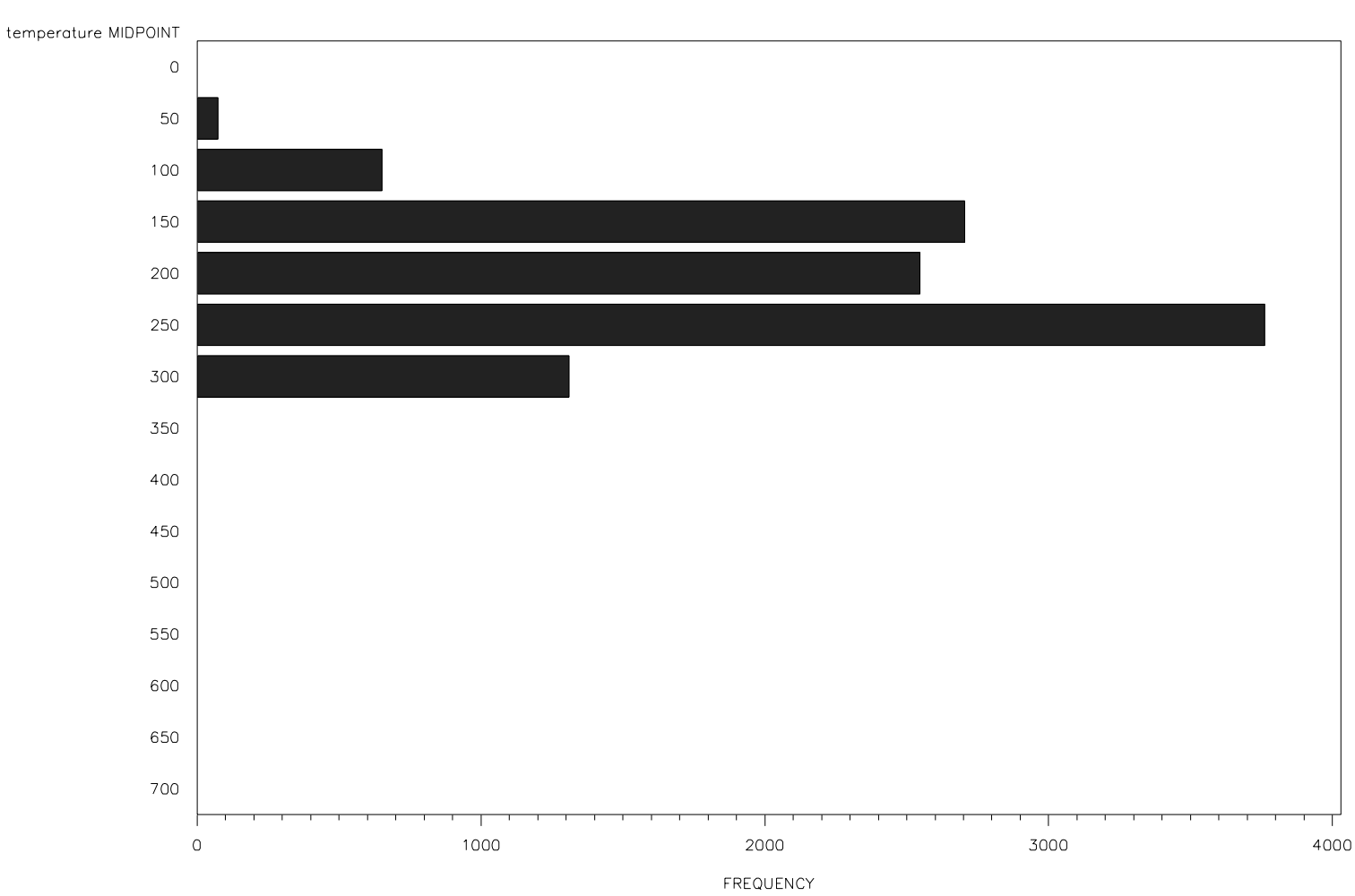
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	30	30	0.25	0.25
100	111	141	0.91	1.16
150	612	753	5.04	6.20
200	1979	2732	16.29	22.48
250	1823	4555	15.00	37.48
300	3336	7891	27.45	64.94
350	3826	11717	31.48	96.42
400	435	12152	3.58	100.00
450	0	12152	0.00	100.00
500	0	12152	0.00	100.00
550	0	12152	0.00	100.00
600	0	12152	0.00	100.00
650	0	12152	0.00	100.00
700	0	12152	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070605_2_Compactor_KieferLandfill



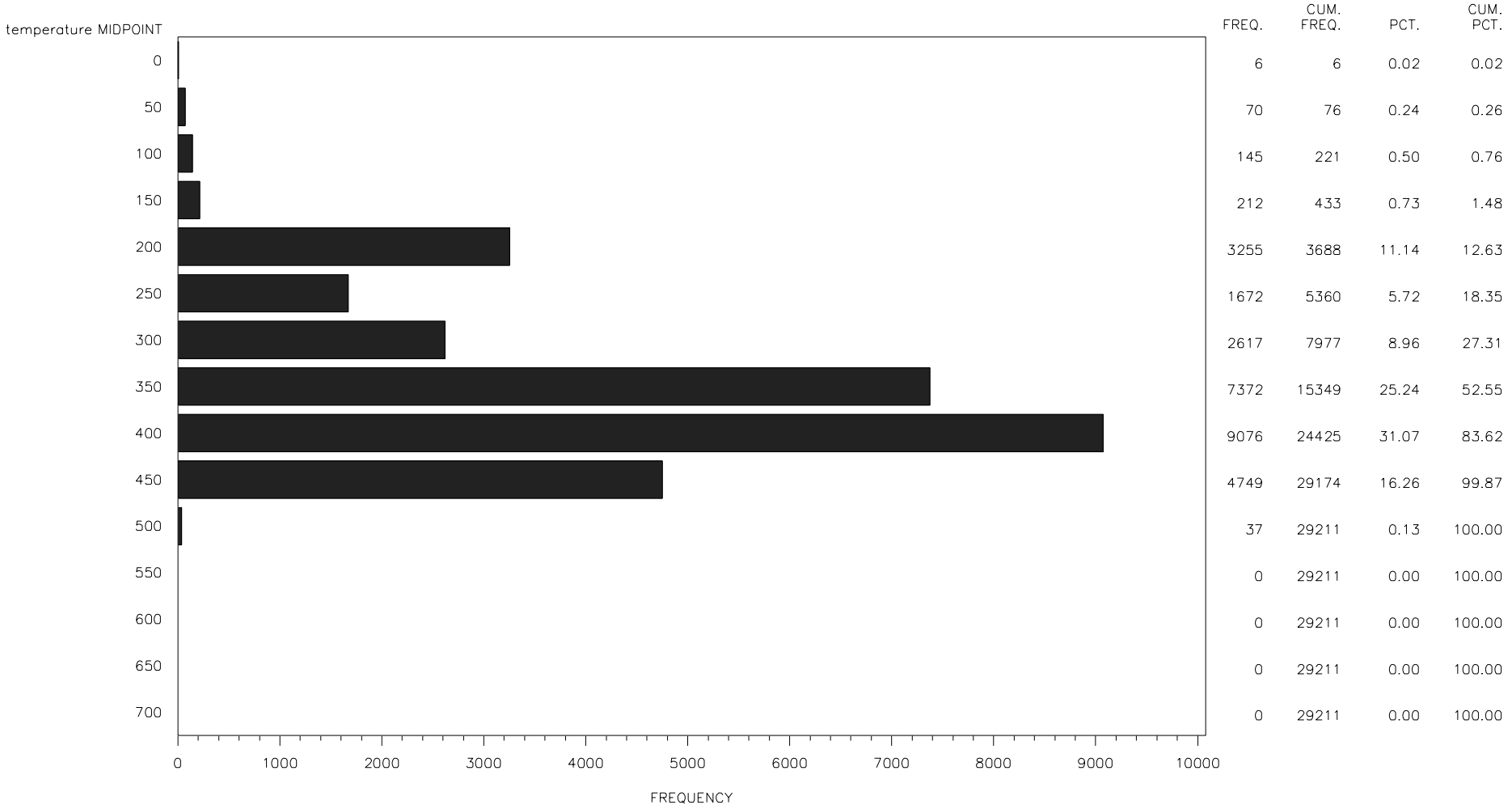
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	100	100	0.15	0.15
100	247	347	0.37	0.52
150	2011	2358	3.01	3.52
200	2086	4444	3.12	6.64
250	2927	7371	4.38	11.02
300	3368	10739	5.03	16.05
350	5186	15925	7.75	23.80
400	21659	37584	32.37	56.18
450	28319	65903	42.33	98.51
500	999	66902	1.49	100.00
550	0	66902	0.00	100.00
600	0	66902	0.00	100.00
650	0	66902	0.00	100.00
700	0	66902	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070605_3_Backhoe_CommercialConstruction



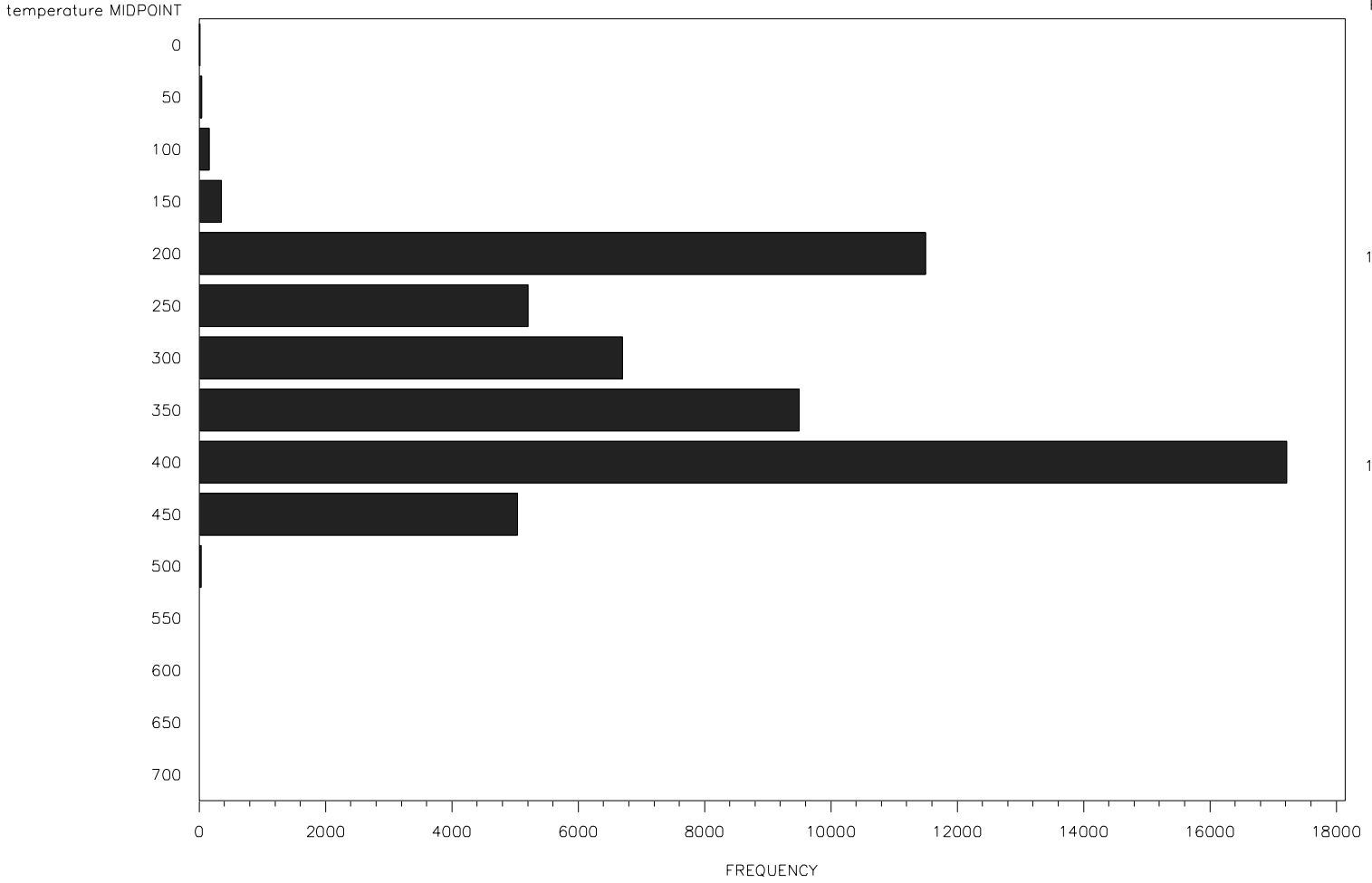
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	74	74	0.67	0.67
100	651	725	5.89	6.56
150	2704	3429	24.48	31.04
200	2547	5976	23.06	54.10
250	3761	9737	34.05	88.14
300	1310	11047	11.86	100.00
350	0	11047	0.00	100.00
400	0	11047	0.00	100.00
450	0	11047	0.00	100.00
500	0	11047	0.00	100.00
550	0	11047	0.00	100.00
600	0	11047	0.00	100.00
650	0	11047	0.00	100.00
700	0	11047	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070606_1_Loader_CommercialConstruction



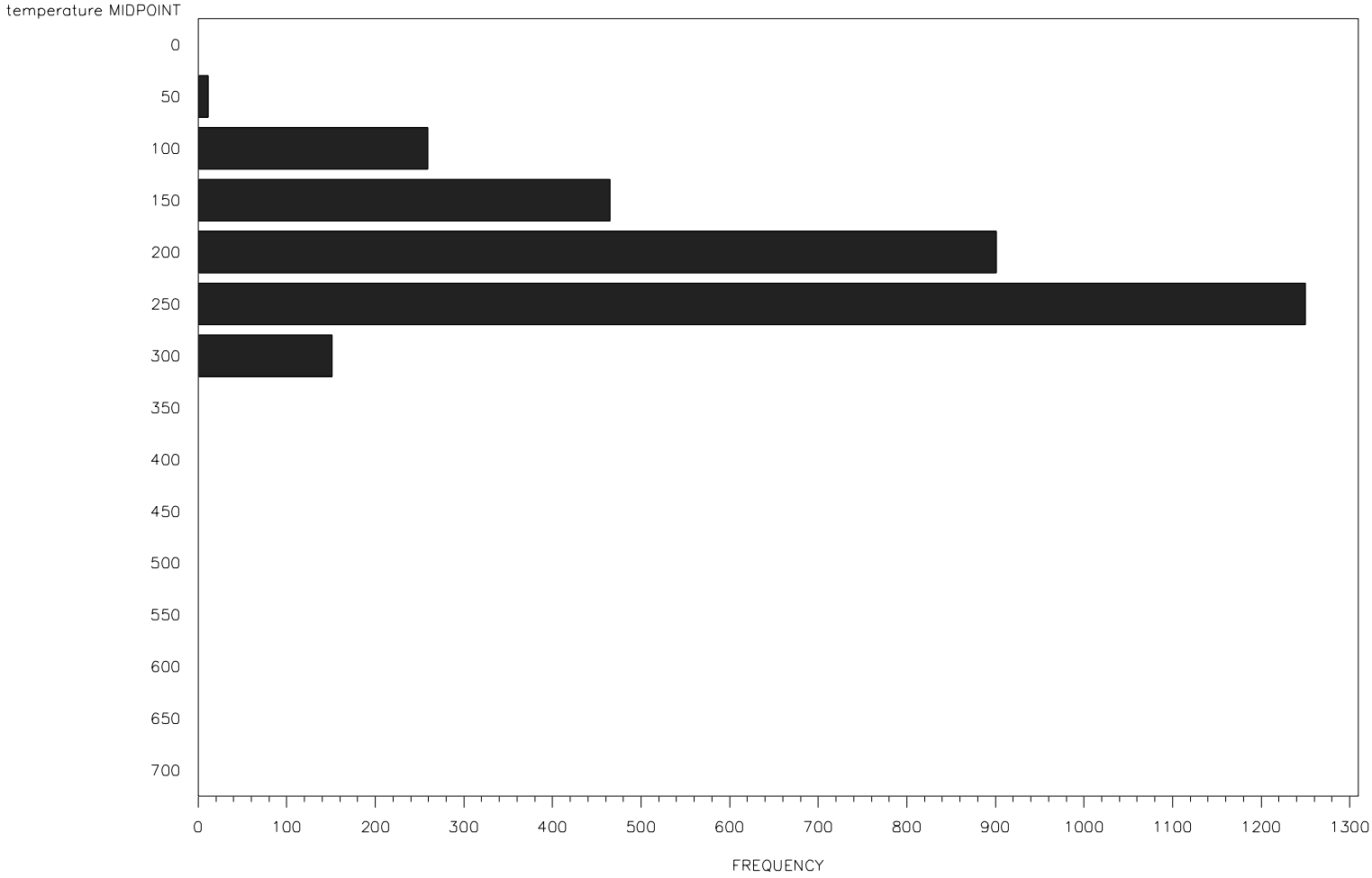
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	6	6	0.02	0.02
50	70	76	0.24	0.26
100	145	221	0.50	0.76
150	212	433	0.73	1.48
200	3255	3688	11.14	12.63
250	1672	5360	5.72	18.35
300	2617	7977	8.96	27.31
350	7372	15349	25.24	52.55
400	9076	24425	31.07	83.62
450	4749	29174	16.26	99.87
500	37	29211	0.13	100.00
550	0	29211	0.00	100.00
600	0	29211	0.00	100.00
650	0	29211	0.00	100.00
700	0	29211	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070606_2_RubberWheelLoader_KieferLandfill



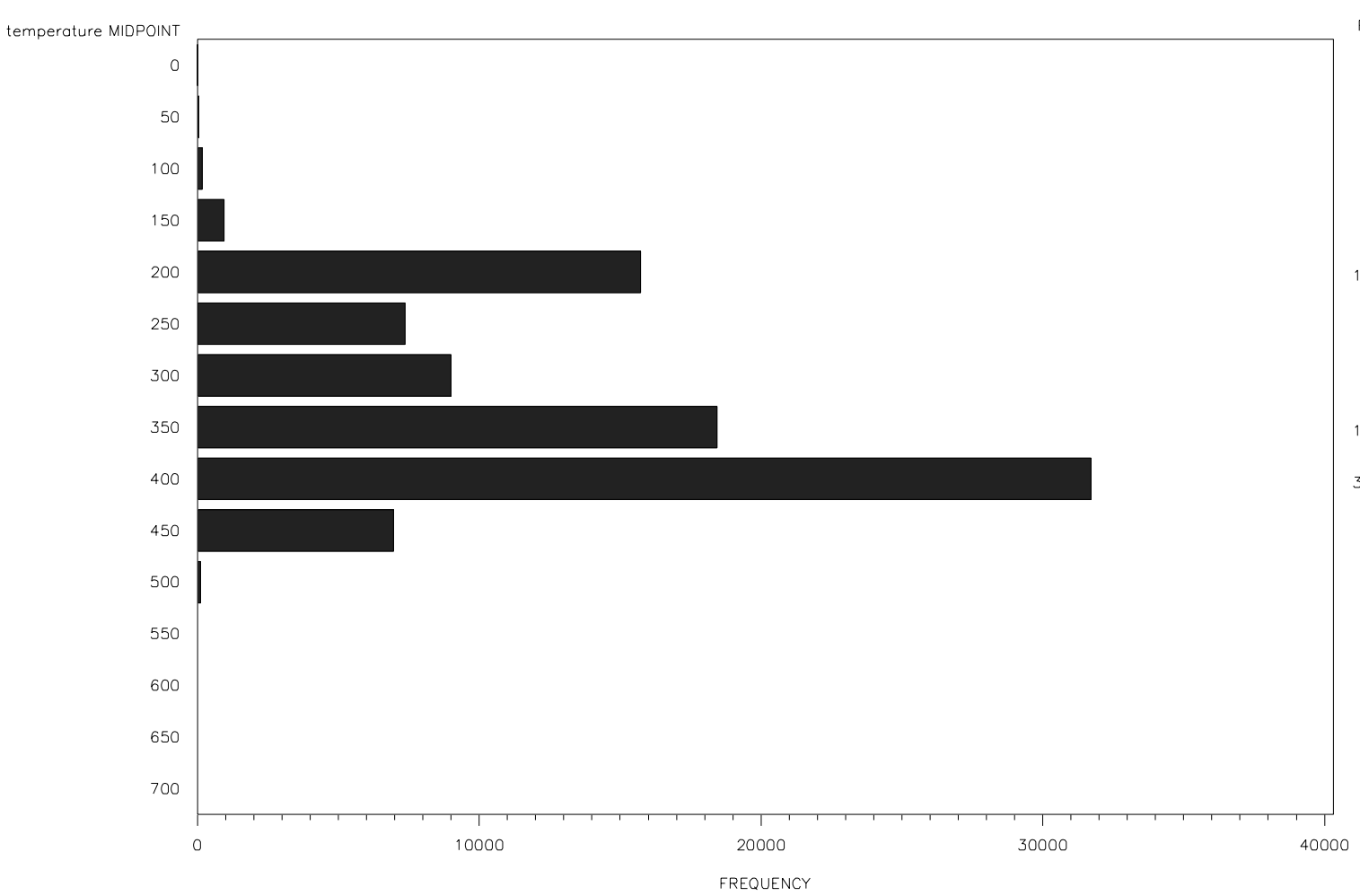
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	7	7	0.01	0.01
50	37	44	0.07	0.08
100	158	202	0.28	0.36
150	346	548	0.62	0.98
200	11494	12042	20.63	21.61
250	5201	17243	9.33	30.94
300	6701	23944	12.02	42.97
350	9499	33443	17.05	60.01
400	17214	50657	30.89	90.90
450	5043	55700	9.05	99.95
500	26	55726	0.05	100.00
550	0	55726	0.00	100.00
600	0	55726	0.00	100.00
650	0	55726	0.00	100.00
700	0	55726	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070607_1_Backhoe_CommercialConstruction



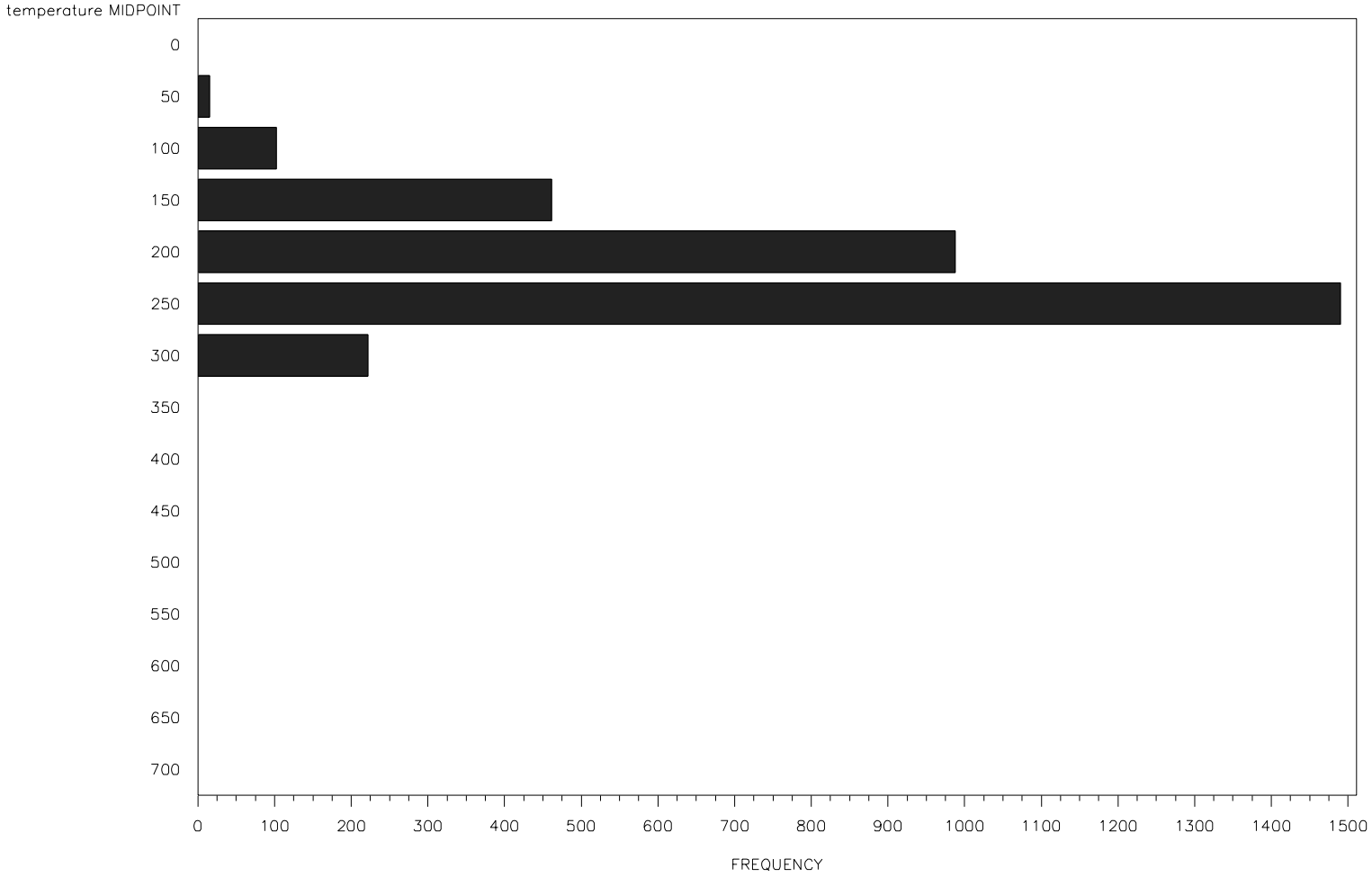
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	11	11	0.36	0.36
100	259	270	8.53	8.89
150	465	735	15.31	24.20
200	901	1636	29.67	53.87
250	1250	2886	41.16	95.03
300	151	3037	4.97	100.00
350	0	3037	0.00	100.00
400	0	3037	0.00	100.00
450	0	3037	0.00	100.00
500	0	3037	0.00	100.00
550	0	3037	0.00	100.00
600	0	3037	0.00	100.00
650	0	3037	0.00	100.00
700	0	3037	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070609_1_Loader_ResidentialConstruction



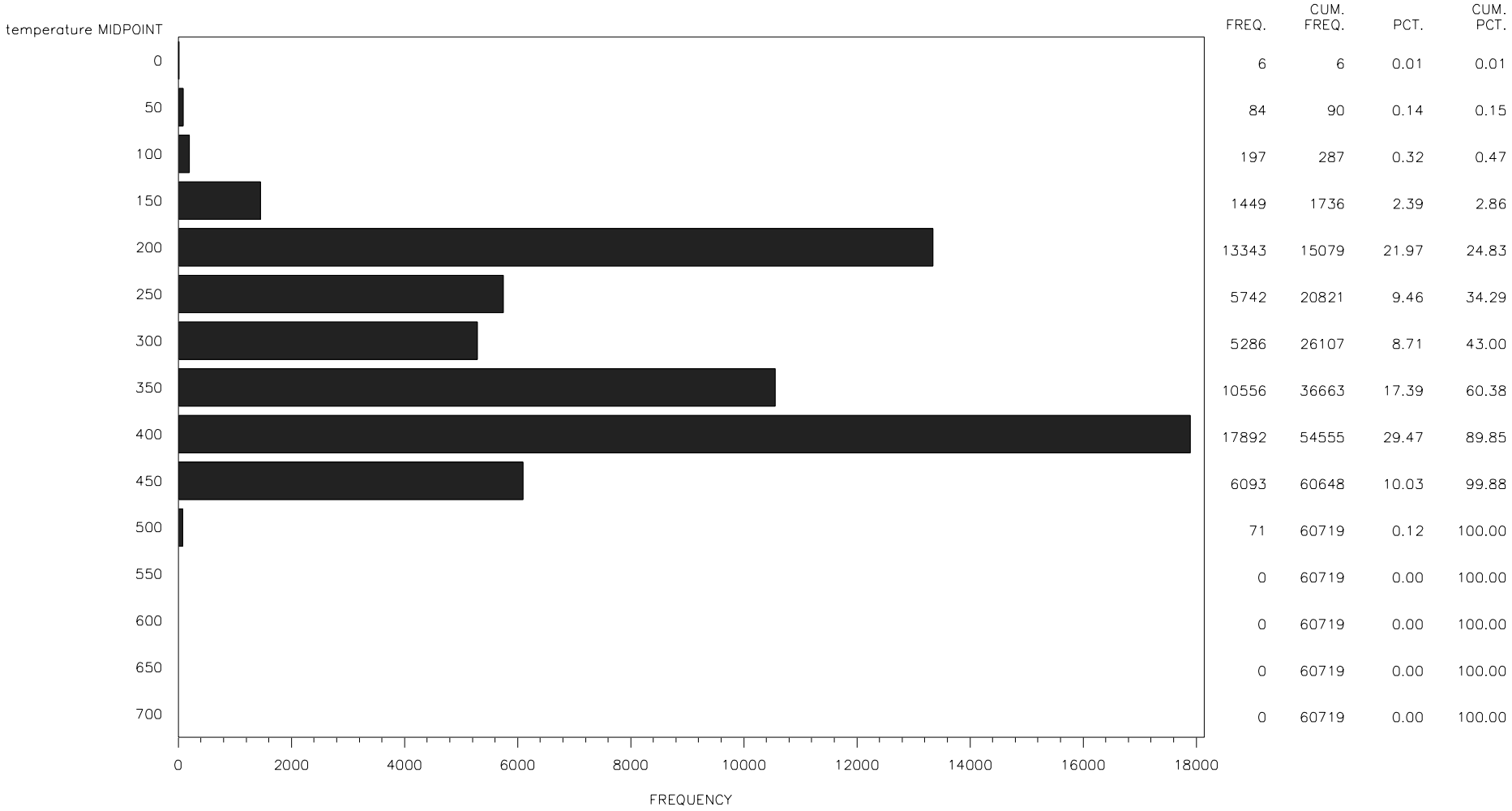
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	6	6	0.01	0.01
50	53	59	0.06	0.07
100	175	234	0.19	0.26
150	939	1173	1.04	1.30
200	15723	16896	17.38	18.68
250	7357	24253	8.13	26.81
300	8986	33239	9.93	36.74
350	18445	51684	20.39	57.13
400	31709	83393	35.05	92.18
450	6963	90356	7.70	99.88
500	107	90463	0.12	100.00
550	0	90463	0.00	100.00
600	0	90463	0.00	100.00
650	0	90463	0.00	100.00
700	0	90463	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070612_1_Backhoe_ResidentialConstruction



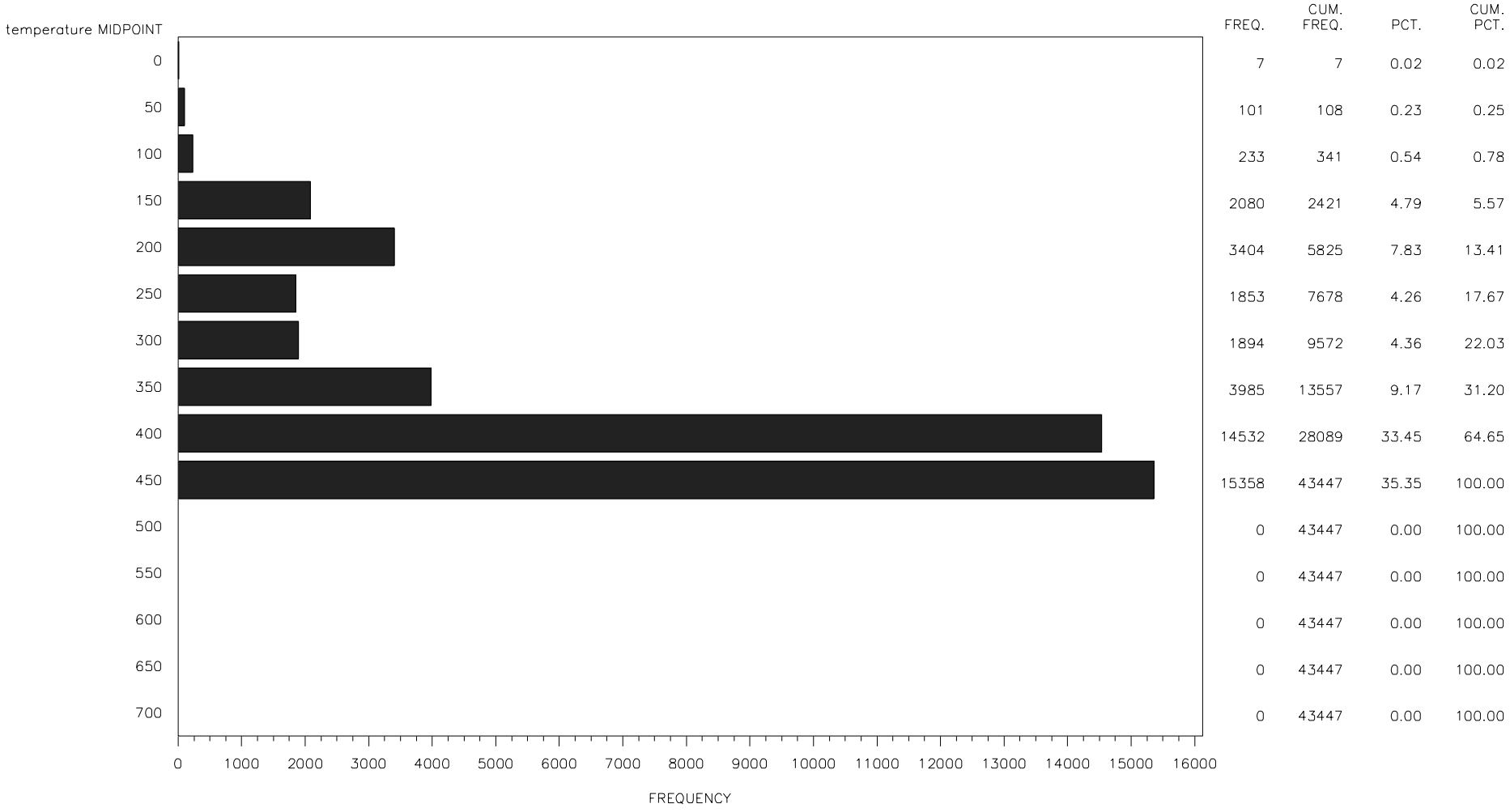
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	15	15	0.46	0.46
100	102	117	3.11	3.57
150	461	578	14.06	17.63
200	988	1566	30.14	47.77
250	1490	3056	45.45	93.23
300	222	3278	6.77	100.00
350	0	3278	0.00	100.00
400	0	3278	0.00	100.00
450	0	3278	0.00	100.00
500	0	3278	0.00	100.00
550	0	3278	0.00	100.00
600	0	3278	0.00	100.00
650	0	3278	0.00	100.00
700	0	3278	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070614_1_Dozer_KieferLandfill



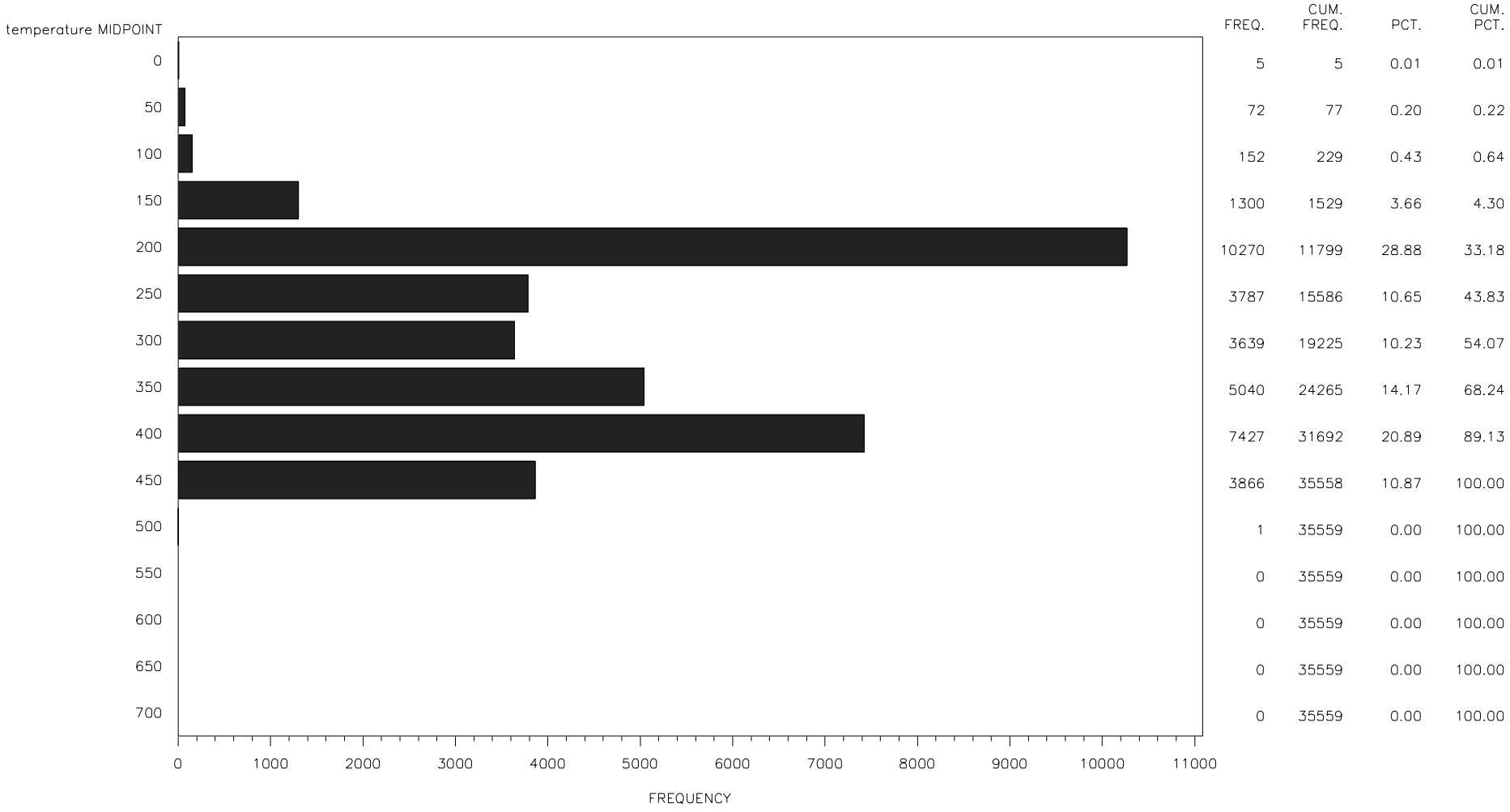
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	6	6	0.01	0.01
50	84	90	0.14	0.15
100	197	287	0.32	0.47
150	1449	1736	2.39	2.86
200	13343	15079	21.97	24.83
250	5742	20821	9.46	34.29
300	5286	26107	8.71	43.00
350	10556	36663	17.39	60.38
400	17892	54555	29.47	89.85
450	6093	60648	10.03	99.88
500	71	60719	0.12	100.00
550	0	60719	0.00	100.00
600	0	60719	0.00	100.00
650	0	60719	0.00	100.00
700	0	60719	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070615_1_Loader_59thStYard



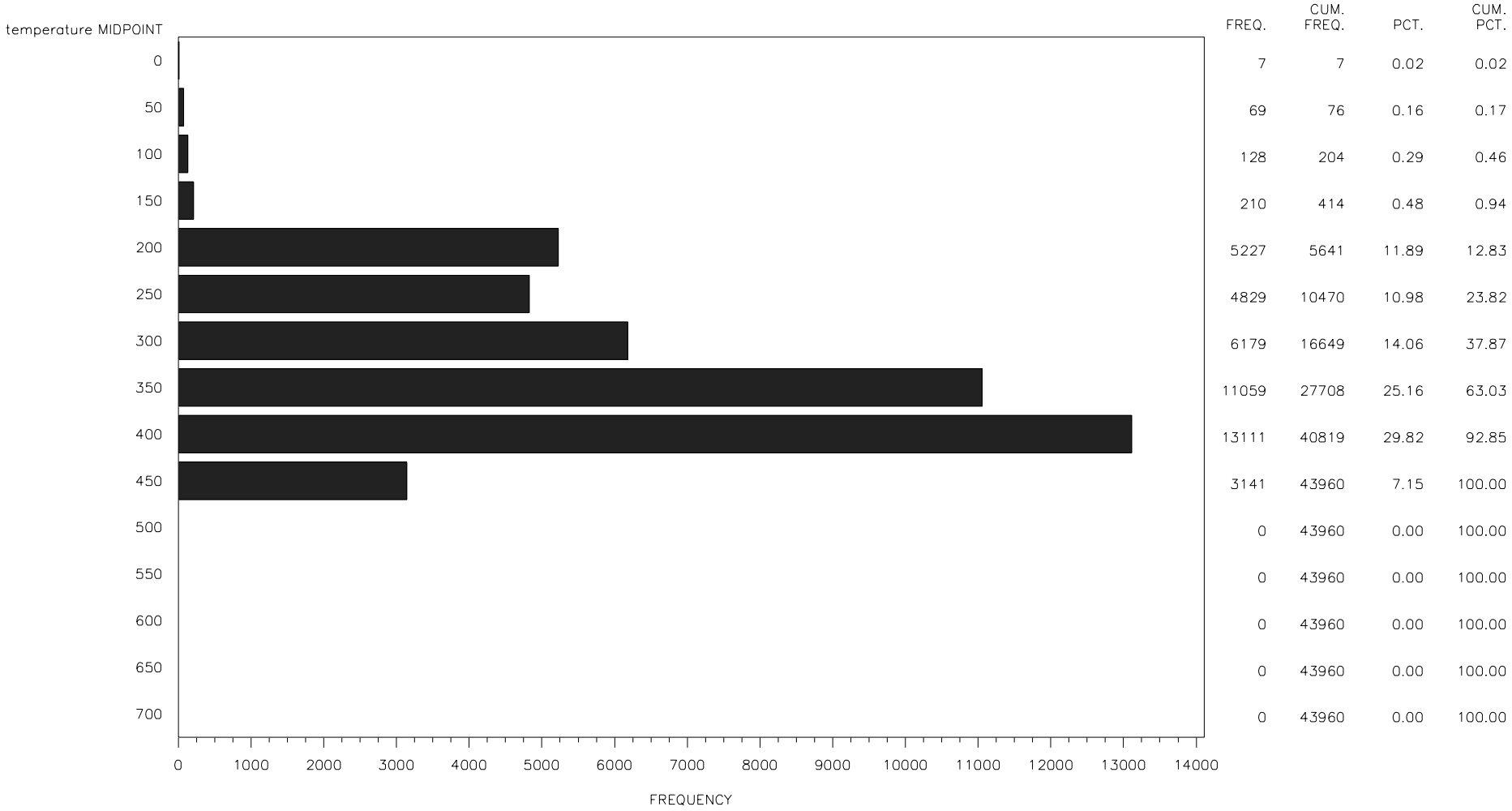
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	7	7	0.02	0.02
50	101	108	0.23	0.25
100	233	341	0.54	0.78
150	2080	2421	4.79	5.57
200	3404	5825	7.83	13.41
250	1853	7678	4.26	17.67
300	1894	9572	4.36	22.03
350	3985	13557	9.17	31.20
400	14532	28089	33.45	64.65
450	15358	43447	35.35	100.00
500	0	43447	0.00	100.00
550	0	43447	0.00	100.00
600	0	43447	0.00	100.00
650	0	43447	0.00	100.00
700	0	43447	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070616_1_Loader_CommercialConstruction



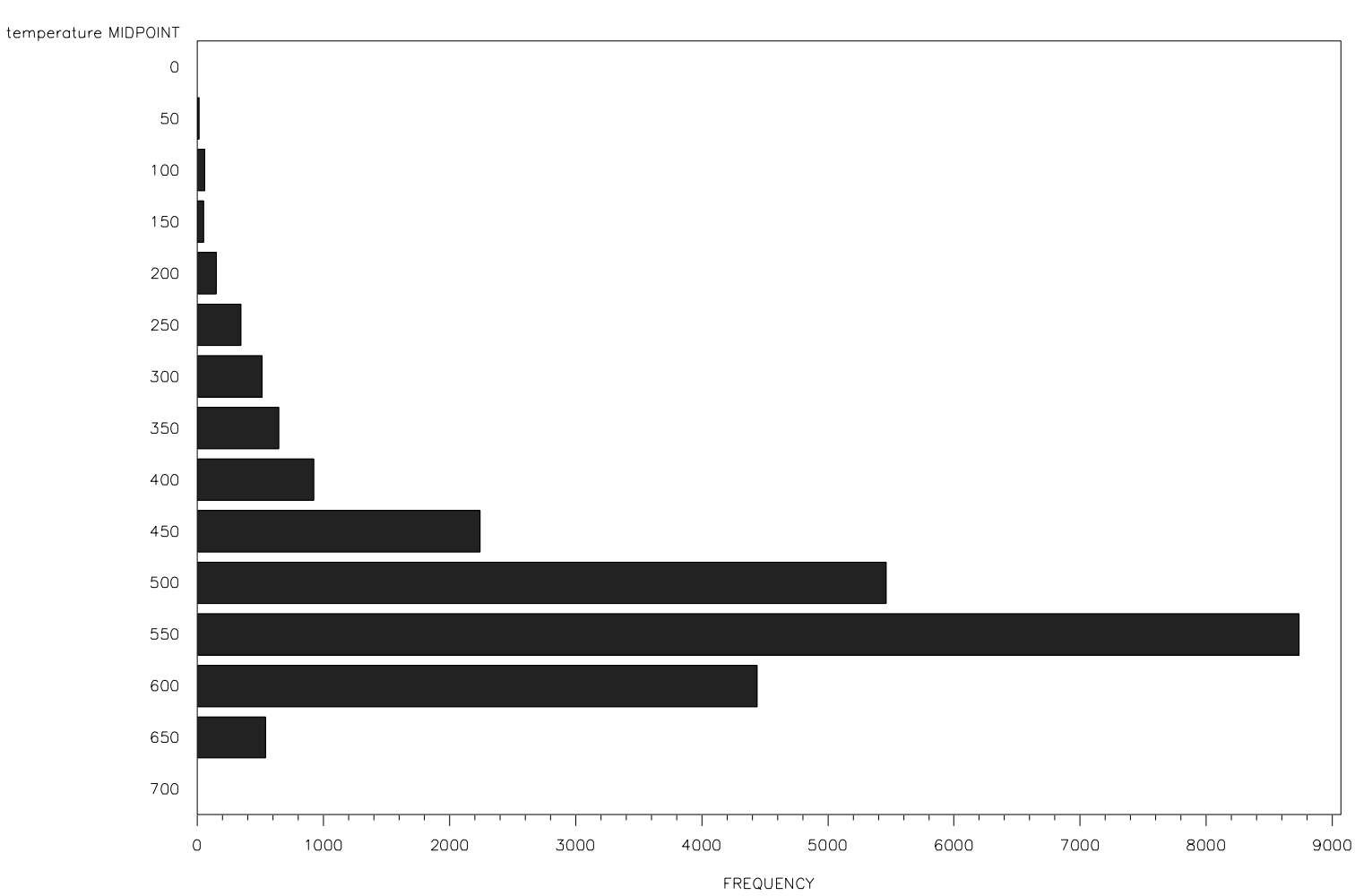
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	5	5	0.01	0.01
50	72	77	0.20	0.22
100	152	229	0.43	0.64
150	1300	1529	3.66	4.30
200	10270	11799	28.88	33.18
250	3787	15586	10.65	43.83
300	3639	19225	10.23	54.07
350	5040	24265	14.17	68.24
400	7427	31692	20.89	89.13
450	3866	35558	10.87	100.00
500	1	35559	0.00	100.00
550	0	35559	0.00	100.00
600	0	35559	0.00	100.00
650	0	35559	0.00	100.00
700	0	35559	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070622_1_Loader_Landfill



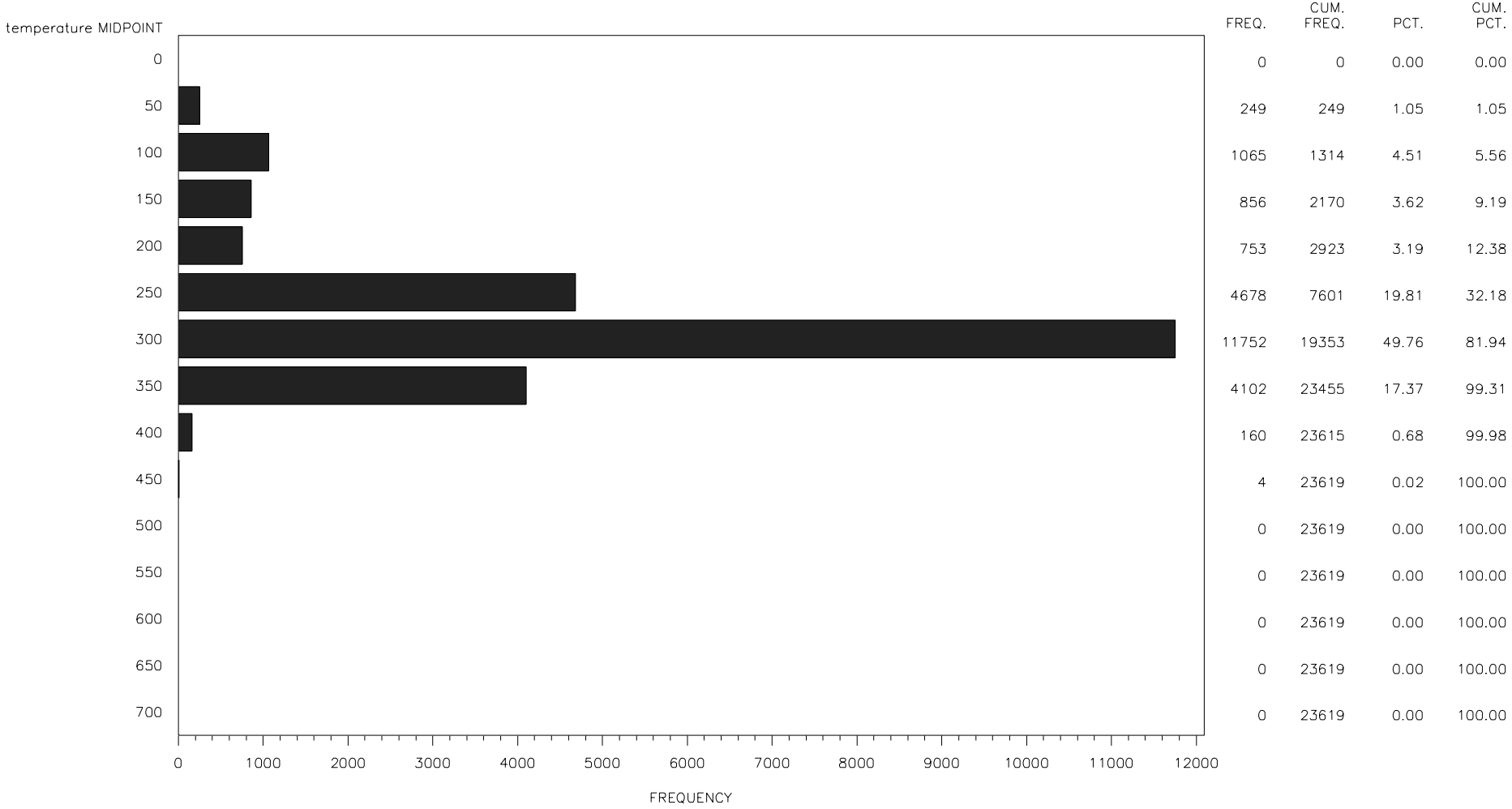
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	7	7	0.02	0.02
50	69	76	0.16	0.17
100	128	204	0.29	0.46
150	210	414	0.48	0.94
200	5227	5641	11.89	12.83
250	4829	10470	10.98	23.82
300	6179	16649	14.06	37.87
350	11059	27708	25.16	63.03
400	13111	40819	29.82	92.85
450	3141	43960	7.15	100.00
500	0	43960	0.00	100.00
550	0	43960	0.00	100.00
600	0	43960	0.00	100.00
650	0	43960	0.00	100.00
700	0	43960	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070624_1_Loader_CommercialConstruction



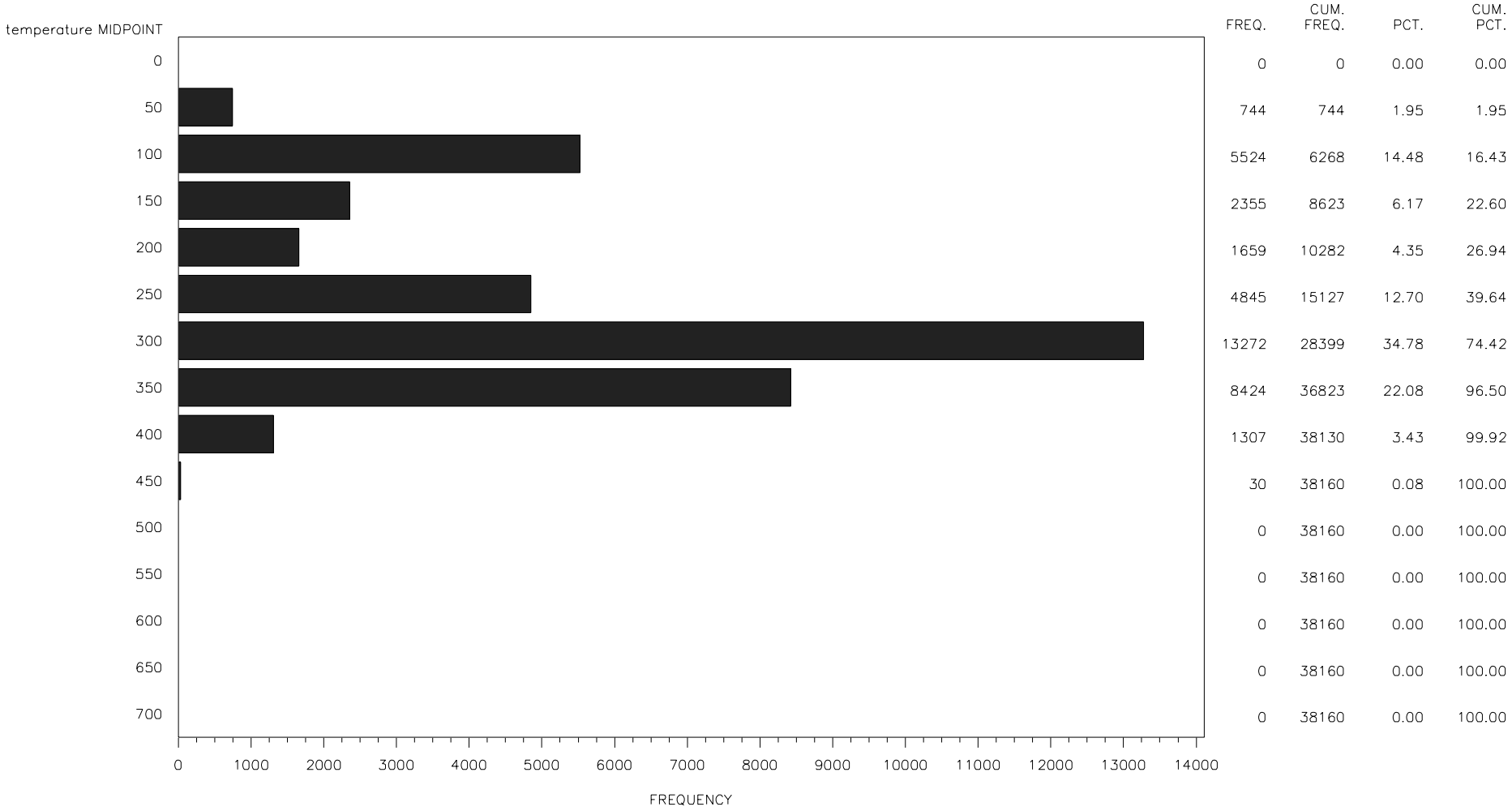
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	13	13	0.05	0.05
100	58	71	0.24	0.29
150	50	121	0.21	0.50
200	151	272	0.63	1.13
250	348	620	1.44	2.57
300	514	1134	2.13	4.70
350	647	1781	2.68	7.38
400	925	2706	3.83	11.22
450	2240	4946	9.29	20.51
500	5463	10409	22.65	43.16
550	8733	19142	36.21	79.36
600	4437	23579	18.40	97.76
650	541	24120	2.24	100.00
700	0	24120	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070628_1_Backhoe_ResidentialConstruction



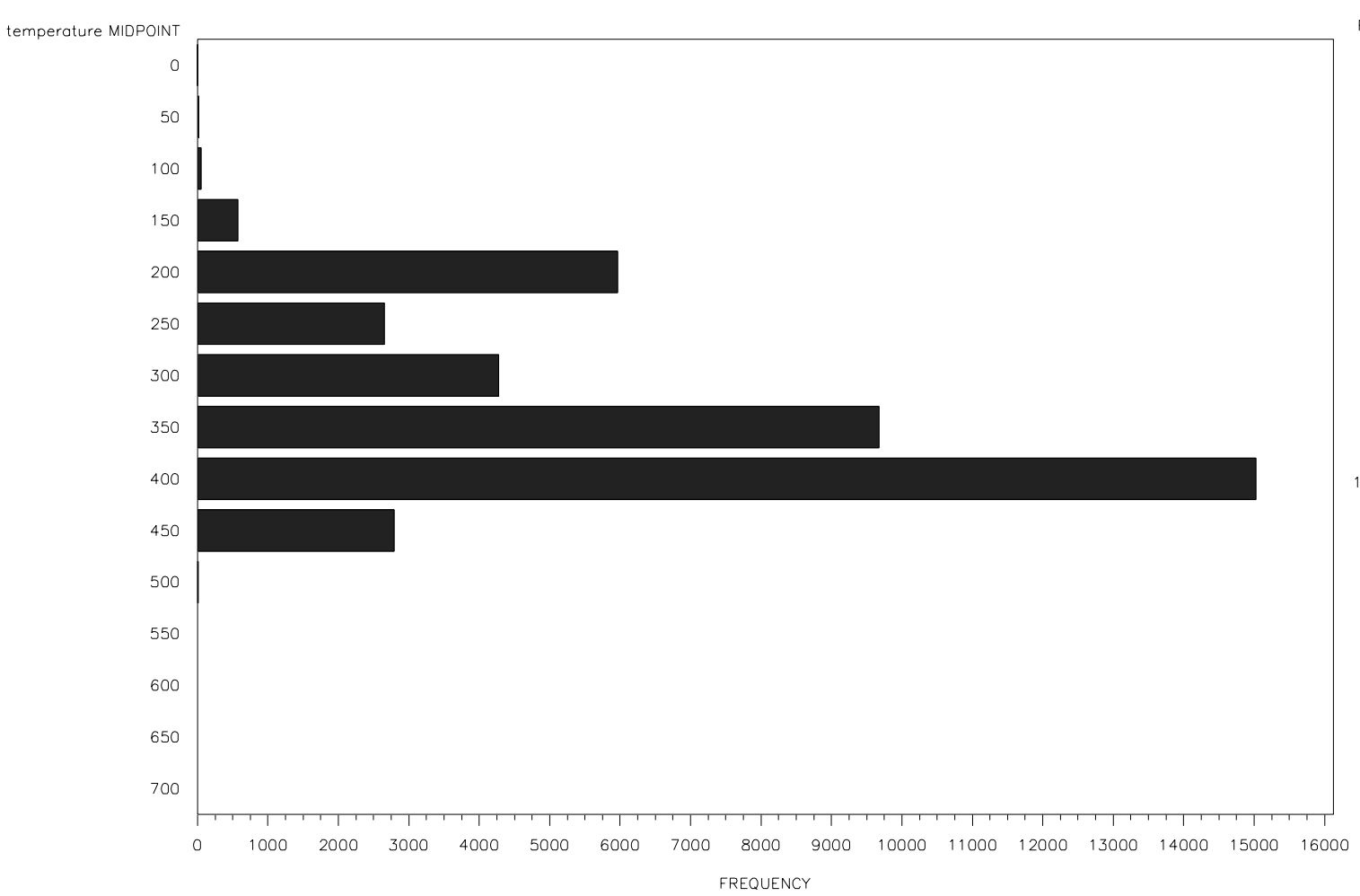
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	249	249	1.05	1.05
100	1065	1314	4.51	5.56
150	856	2170	3.62	9.19
200	753	2923	3.19	12.38
250	4678	7601	19.81	32.18
300	11752	19353	49.76	81.94
350	4102	23455	17.37	99.31
400	160	23615	0.68	99.98
450	4	23619	0.02	100.00
500	0	23619	0.00	100.00
550	0	23619	0.00	100.00
600	0	23619	0.00	100.00
650	0	23619	0.00	100.00
700	0	23619	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070705_1_Backhoe_ResidentialConstruction



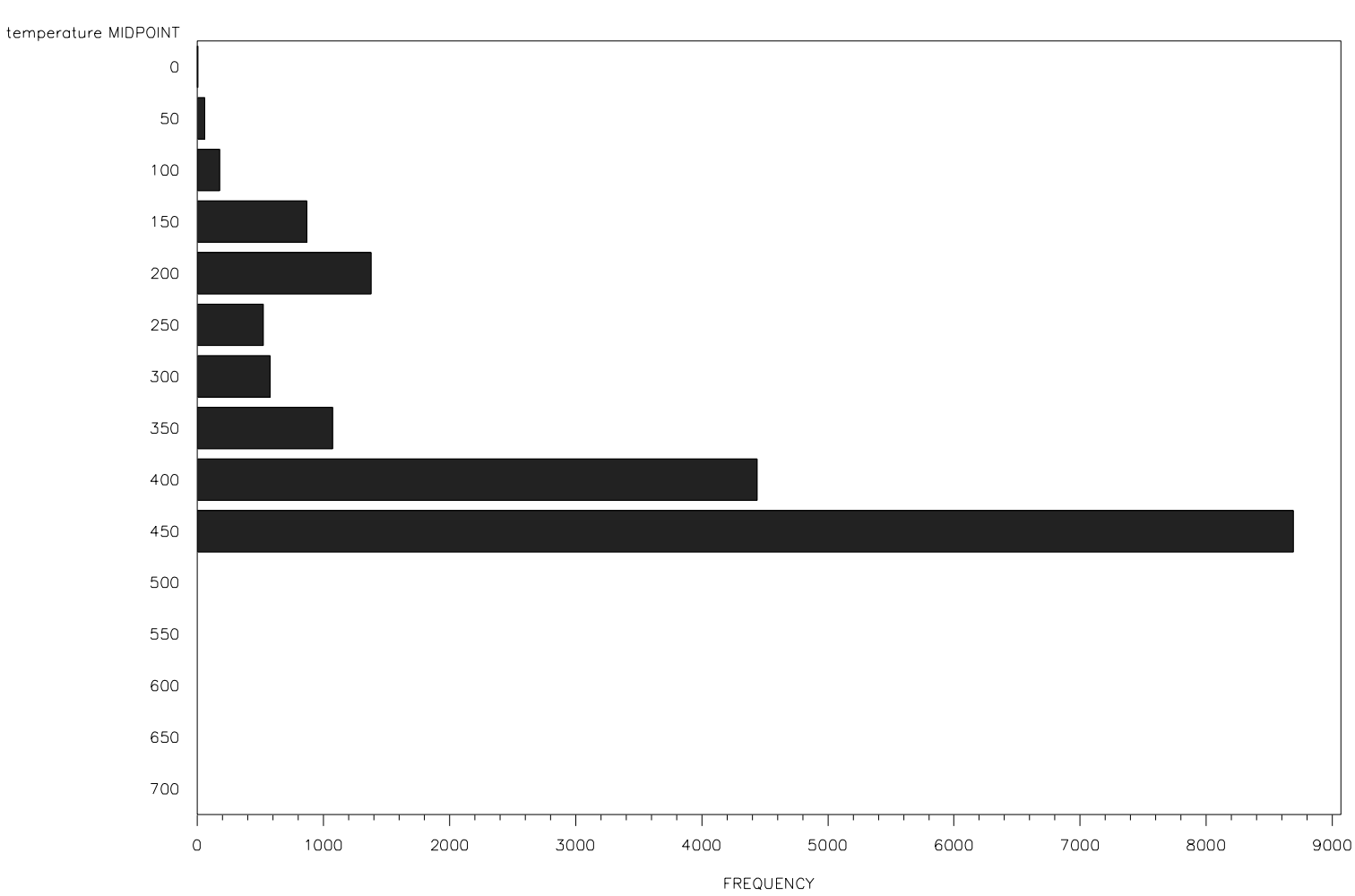
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	744	744	1.95	1.95
100	5524	6268	14.48	16.43
150	2355	8623	6.17	22.60
200	1659	10282	4.35	26.94
250	4845	15127	12.70	39.64
300	13272	28399	34.78	74.42
350	8424	36823	22.08	96.50
400	1307	38130	3.43	99.92
450	30	38160	0.08	100.00
500	0	38160	0.00	100.00
550	0	38160	0.00	100.00
600	0	38160	0.00	100.00
650	0	38160	0.00	100.00
700	0	38160	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070709_1_RubberWheelLoader_CommercialConstruction



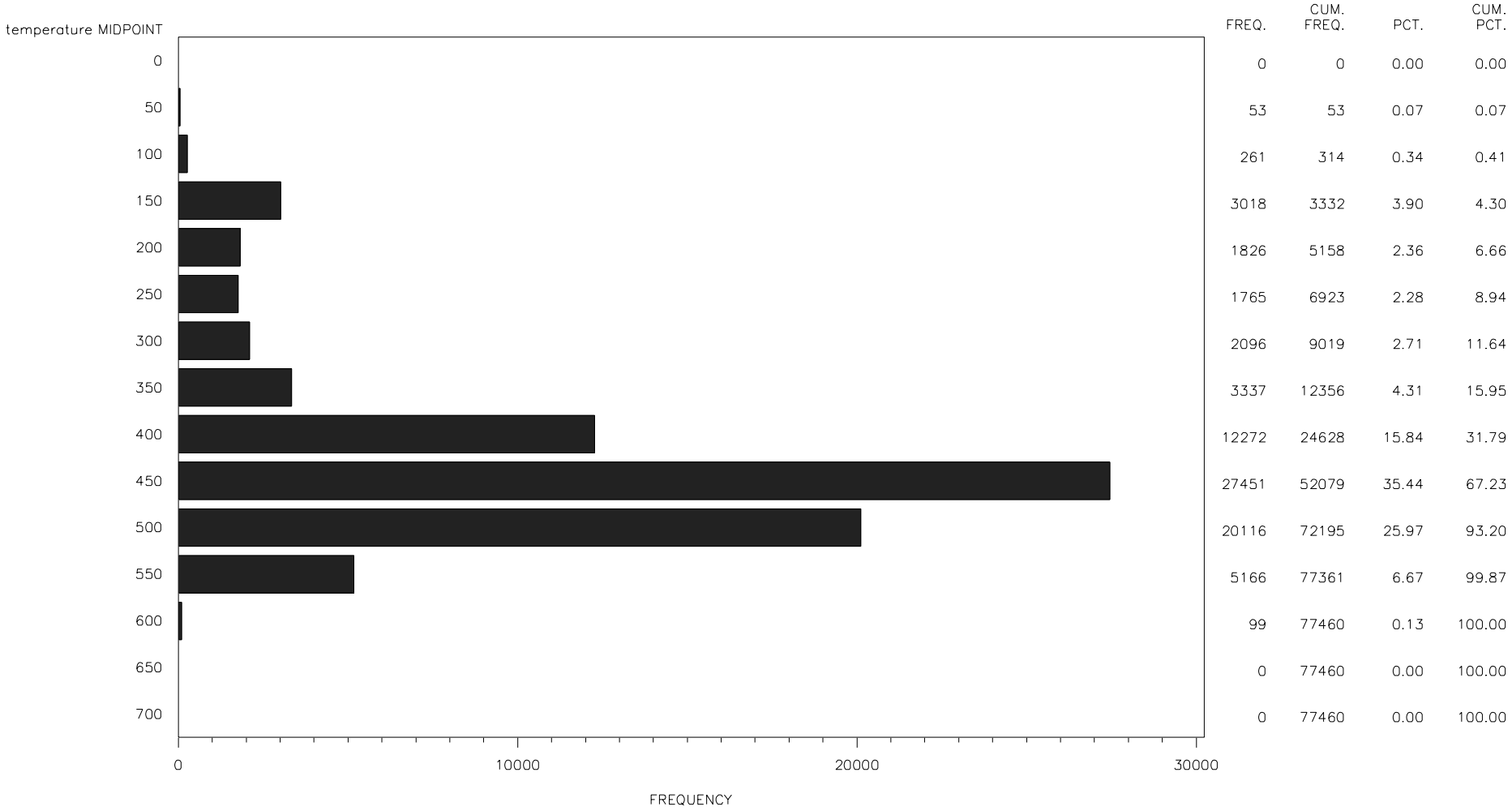
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	2	2	0.00	0.00
50	20	22	0.05	0.05
100	51	73	0.12	0.18
150	573	646	1.40	1.57
200	5965	6611	14.54	16.11
250	2652	9263	6.46	22.57
300	4272	13535	10.41	32.99
350	9672	23207	23.57	56.56
400	15021	38228	36.61	93.16
450	2794	41022	6.81	99.97
500	11	41033	0.03	100.00
550	0	41033	0.00	100.00
600	0	41033	0.00	100.00
650	0	41033	0.00	100.00
700	0	41033	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070716_1_Loader_KieferLandfill



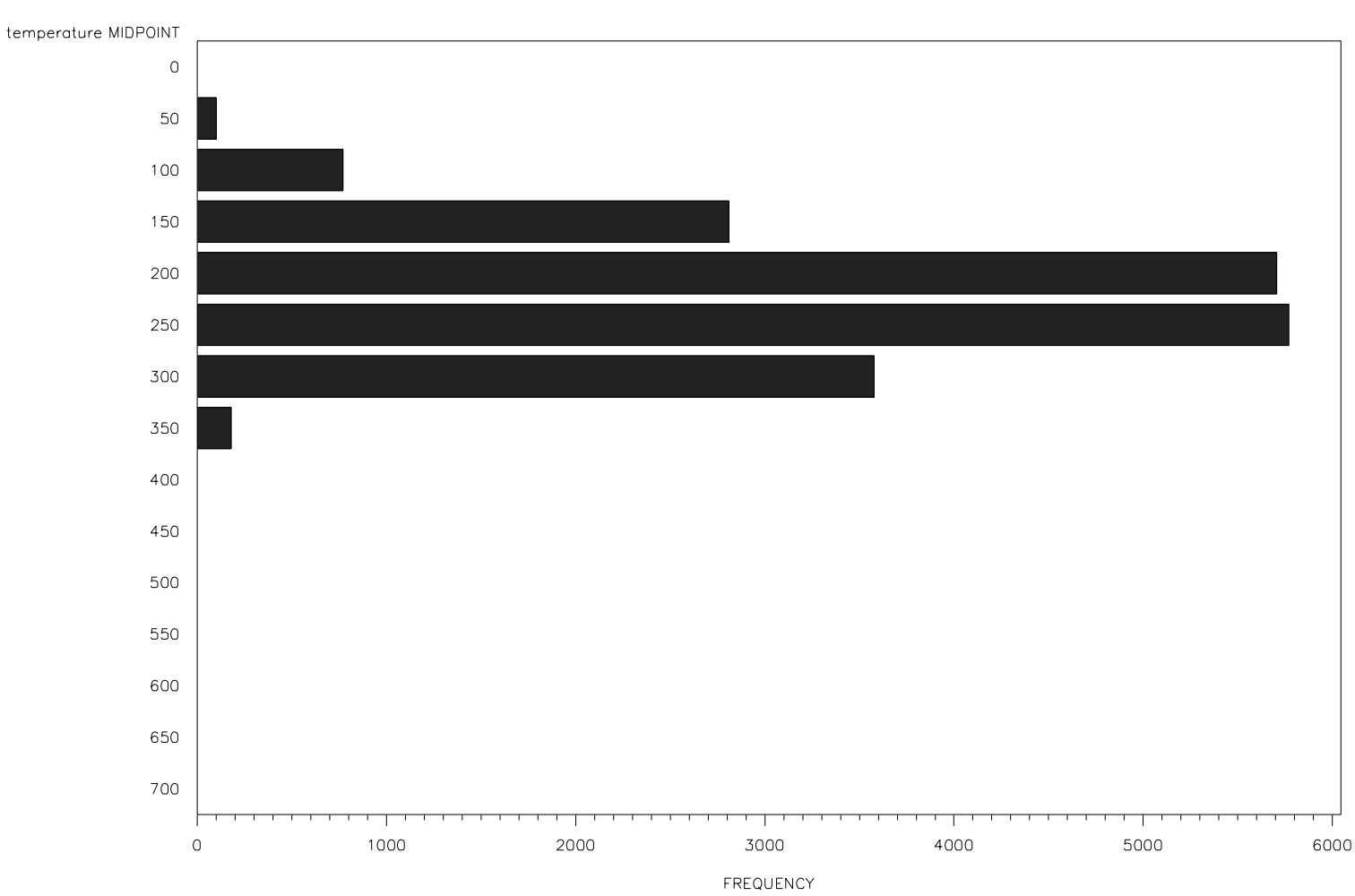
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	6	6	0.03	0.03
50	61	67	0.34	0.38
100	177	244	0.99	1.37
150	871	1115	4.89	6.26
200	1378	2493	7.74	14.01
250	525	3018	2.95	16.96
300	579	3597	3.25	20.21
350	1073	4670	6.03	26.24
400	4440	9110	24.95	51.19
450	8688	17798	48.81	100.00
500	0	17798	0.00	100.00
550	0	17798	0.00	100.00
600	0	17798	0.00	100.00
650	0	17798	0.00	100.00
700	0	17798	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070718_1_Loader_PublicWorks



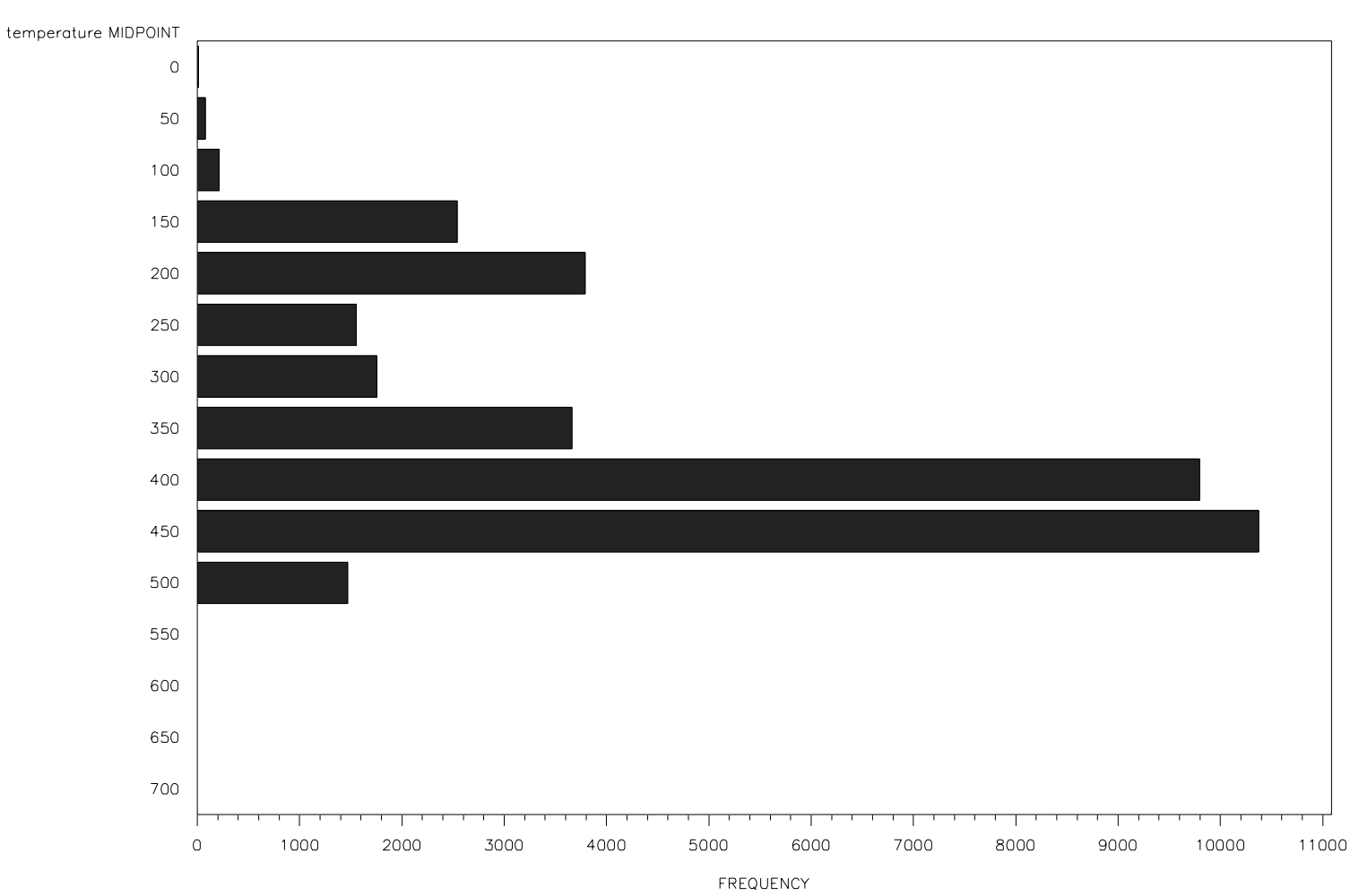
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	53	53	0.07	0.07
100	261	314	0.34	0.41
150	3018	3332	3.90	4.30
200	1826	5158	2.36	6.66
250	1765	6923	2.28	8.94
300	2096	9019	2.71	11.64
350	3337	12356	4.31	15.95
400	12272	24628	15.84	31.79
450	27451	52079	35.44	67.23
500	20116	72195	25.97	93.20
550	5166	77361	6.67	99.87
600	99	77460	0.13	100.00
650	0	77460	0.00	100.00
700	0	77460	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070729_1_Backhoe_CommercialConstruction



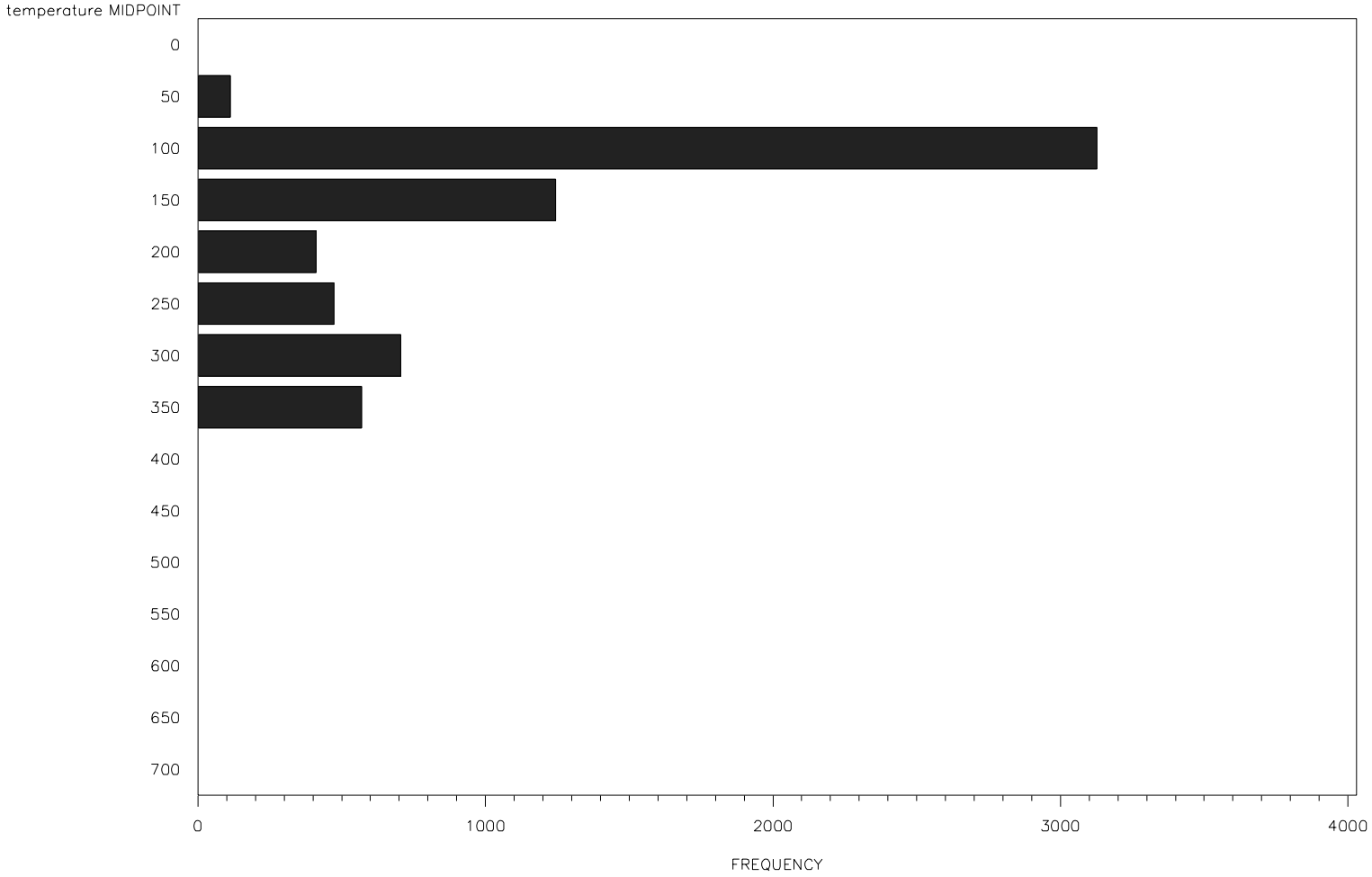
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	100	100	0.53	0.53
100	770	870	4.07	4.60
150	2809	3679	14.86	19.46
200	5705	9384	30.17	49.63
250	5770	15154	30.51	80.14
300	3576	18730	18.91	99.05
350	179	18909	0.95	100.00
400	0	18909	0.00	100.00
450	0	18909	0.00	100.00
500	0	18909	0.00	100.00
550	0	18909	0.00	100.00
600	0	18909	0.00	100.00
650	0	18909	0.00	100.00
700	0	18909	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070803_1_WheelLoader_WasteWaterTreatment



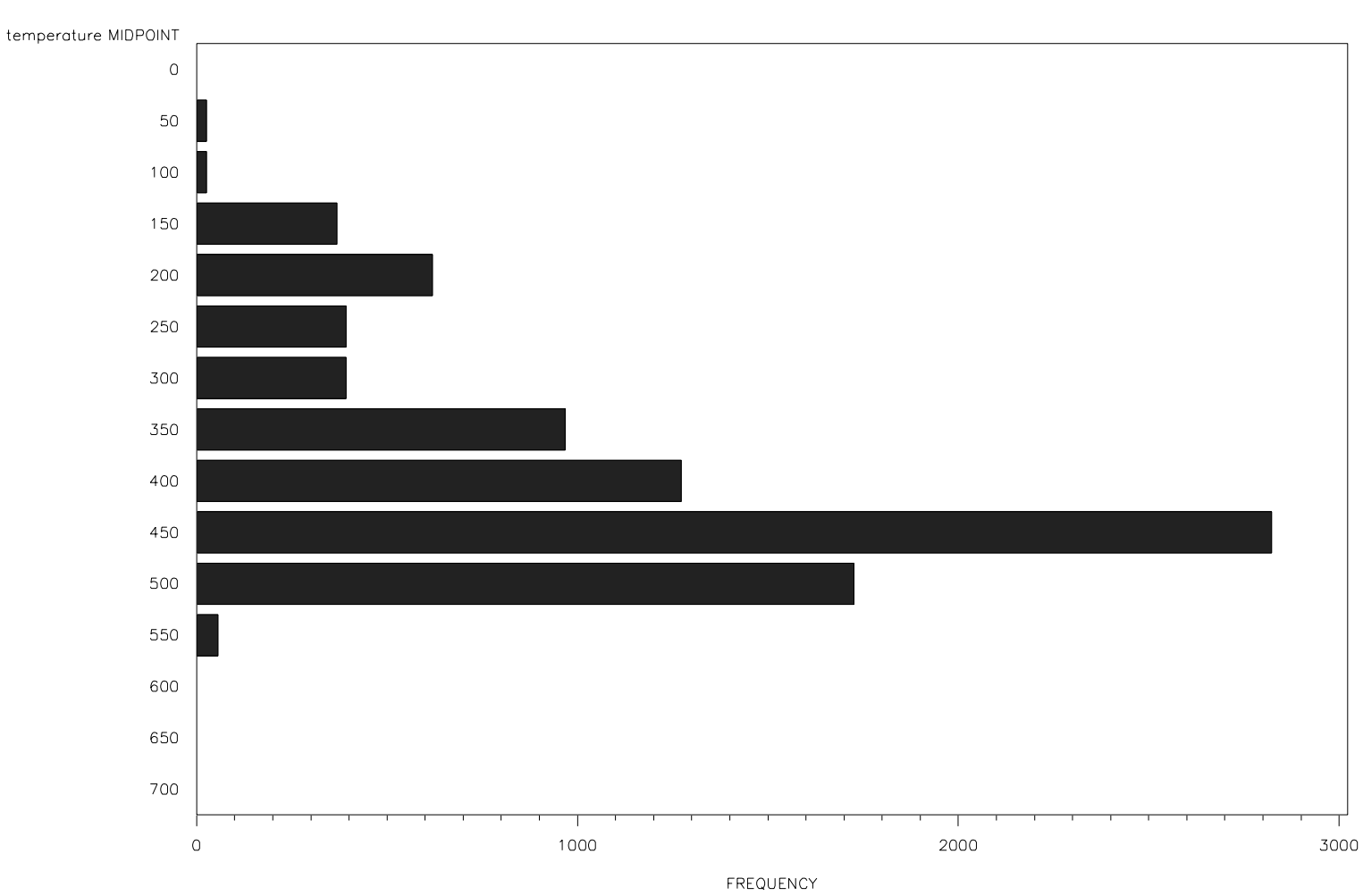
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	12	12	0.03	0.03
50	82	94	0.23	0.27
100	216	310	0.61	0.88
150	2542	2852	7.21	8.09
200	3794	6646	10.76	18.85
250	1552	8198	4.40	23.25
300	1756	9954	4.98	28.23
350	3662	13616	10.39	38.62
400	9796	23412	27.79	66.41
450	10372	33784	29.42	95.82
500	1472	35256	4.18	100.00
550	0	35256	0.00	100.00
600	0	35256	0.00	100.00
650	0	35256	0.00	100.00
700	0	35256	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070823_1_Backhoe_CommercialConstruction



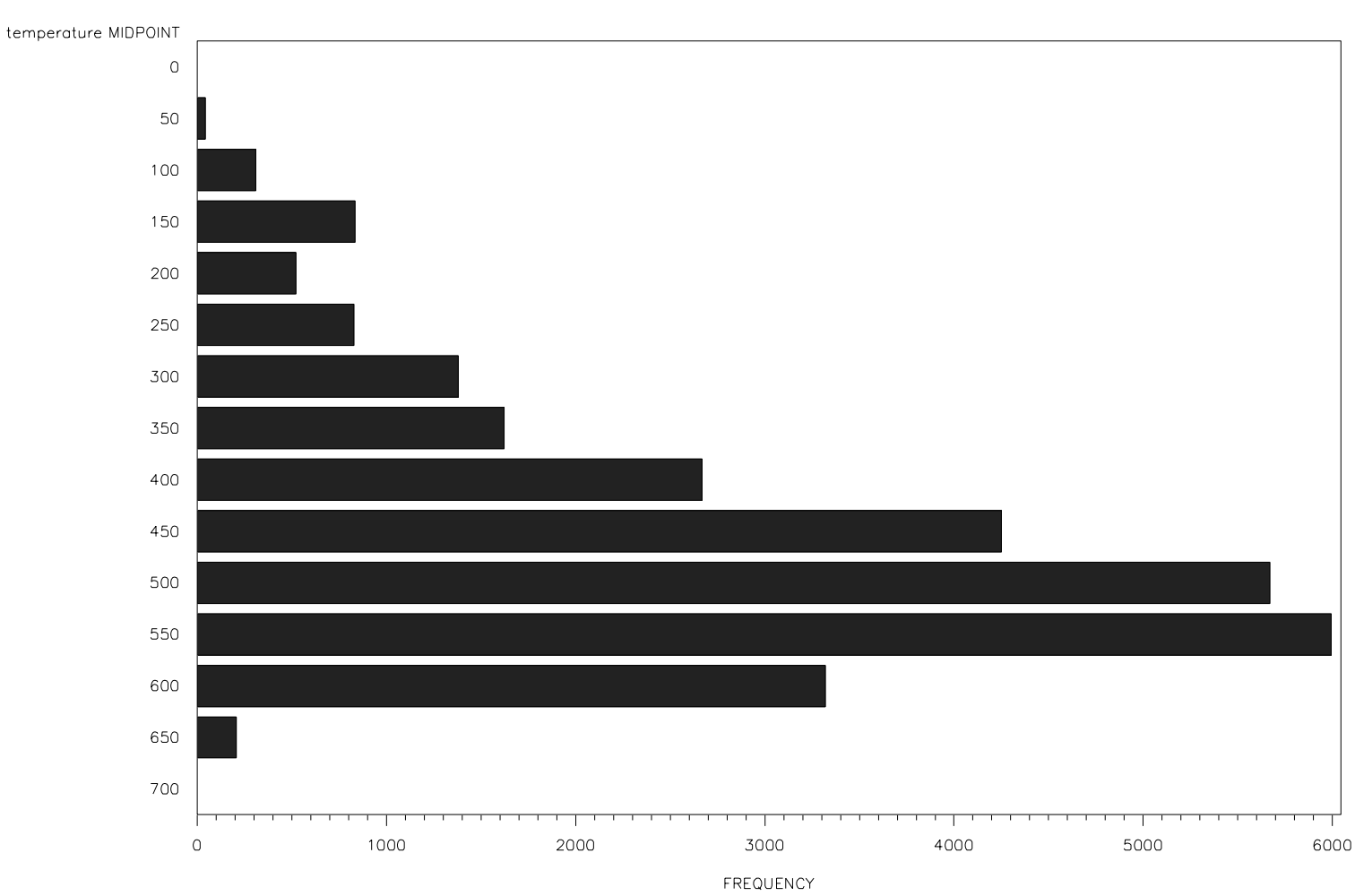
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	113	113	1.70	1.70
100	3126	3239	47.07	48.77
150	1244	4483	18.73	67.50
200	411	4894	6.19	73.69
250	472	5366	7.11	80.80
300	706	6072	10.63	91.43
350	569	6641	8.57	100.00
400	0	6641	0.00	100.00
450	0	6641	0.00	100.00
500	0	6641	0.00	100.00
550	0	6641	0.00	100.00
600	0	6641	0.00	100.00
650	0	6641	0.00	100.00
700	0	6641	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070824_1_WheelLoader_WasteWaterTreatment



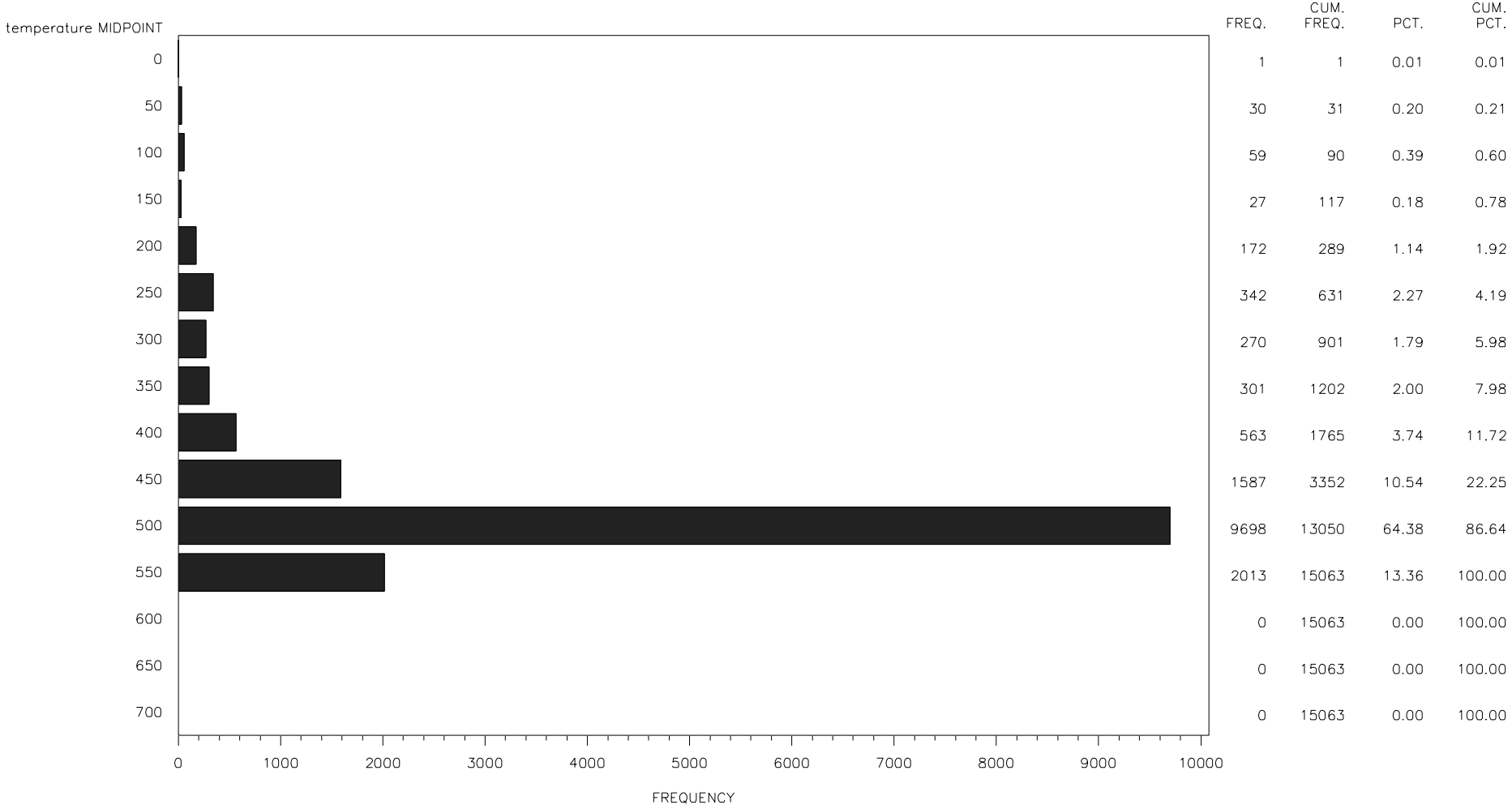
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	25	25	0.29	0.29
100	26	51	0.30	0.59
150	368	419	4.25	4.84
200	619	1038	7.14	11.98
250	392	1430	4.52	16.50
300	392	1822	4.52	21.03
350	967	2789	11.16	32.19
400	1272	4061	14.68	46.87
450	2822	6883	32.57	79.43
500	1726	8609	19.92	99.35
550	56	8665	0.65	100.00
600	0	8665	0.00	100.00
650	0	8665	0.00	100.00
700	0	8665	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070824_2_Scraper_WasteWaterTreatment



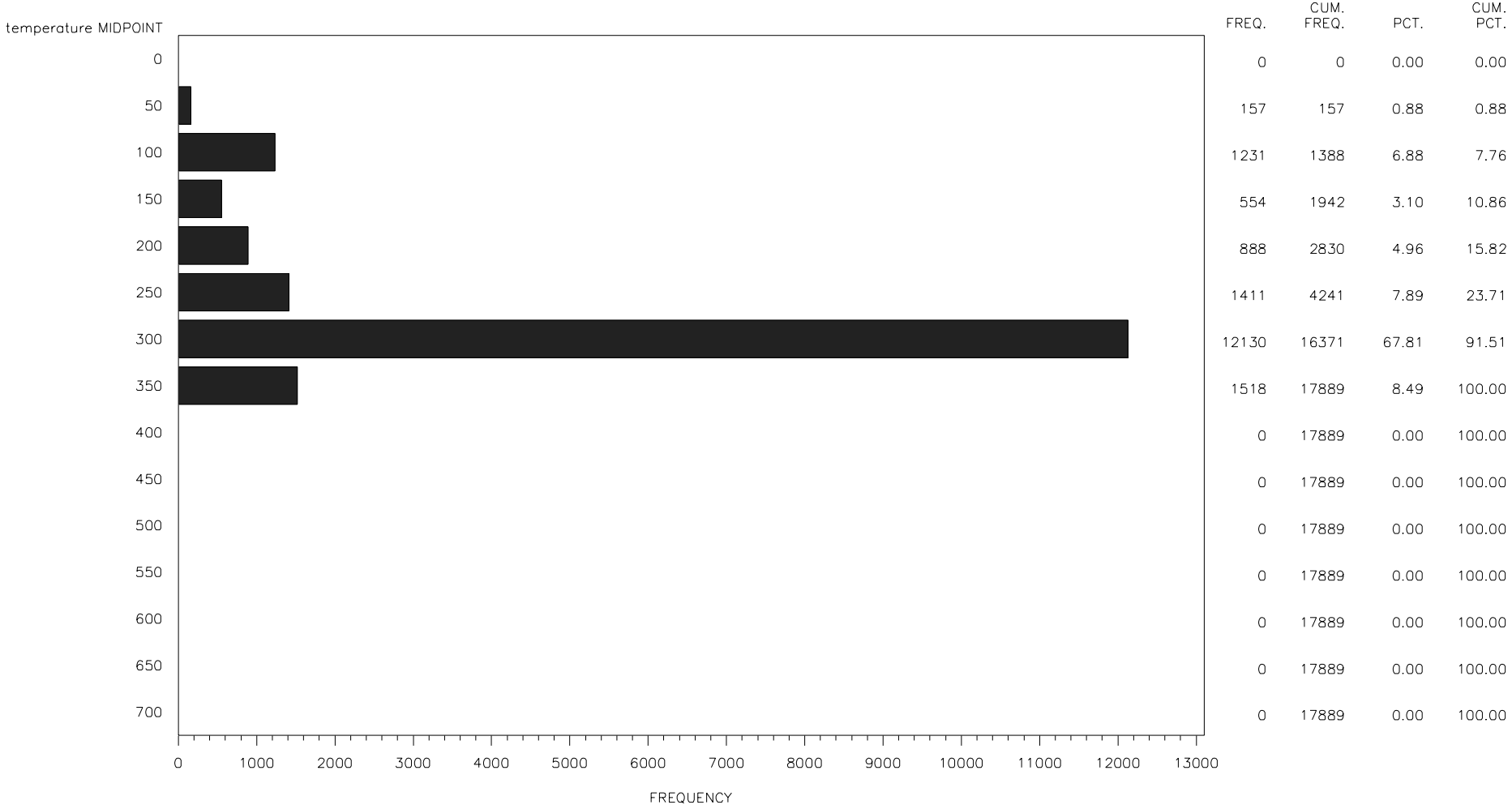
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	42	42	0.15	0.15
100	311	353	1.12	1.28
150	834	1187	3.02	4.29
200	523	1710	1.89	6.19
250	829	2539	3.00	9.18
300	1380	3919	4.99	14.18
350	1623	5542	5.87	20.05
400	2668	8210	9.65	29.70
450	4249	12459	15.37	45.07
500	5668	18127	20.50	65.57
550	5992	24119	21.67	87.24
600	3321	27440	12.01	99.25
650	206	27646	0.75	100.00
700	0	27646	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070824_3_Dozer_WasteWaterTreatment



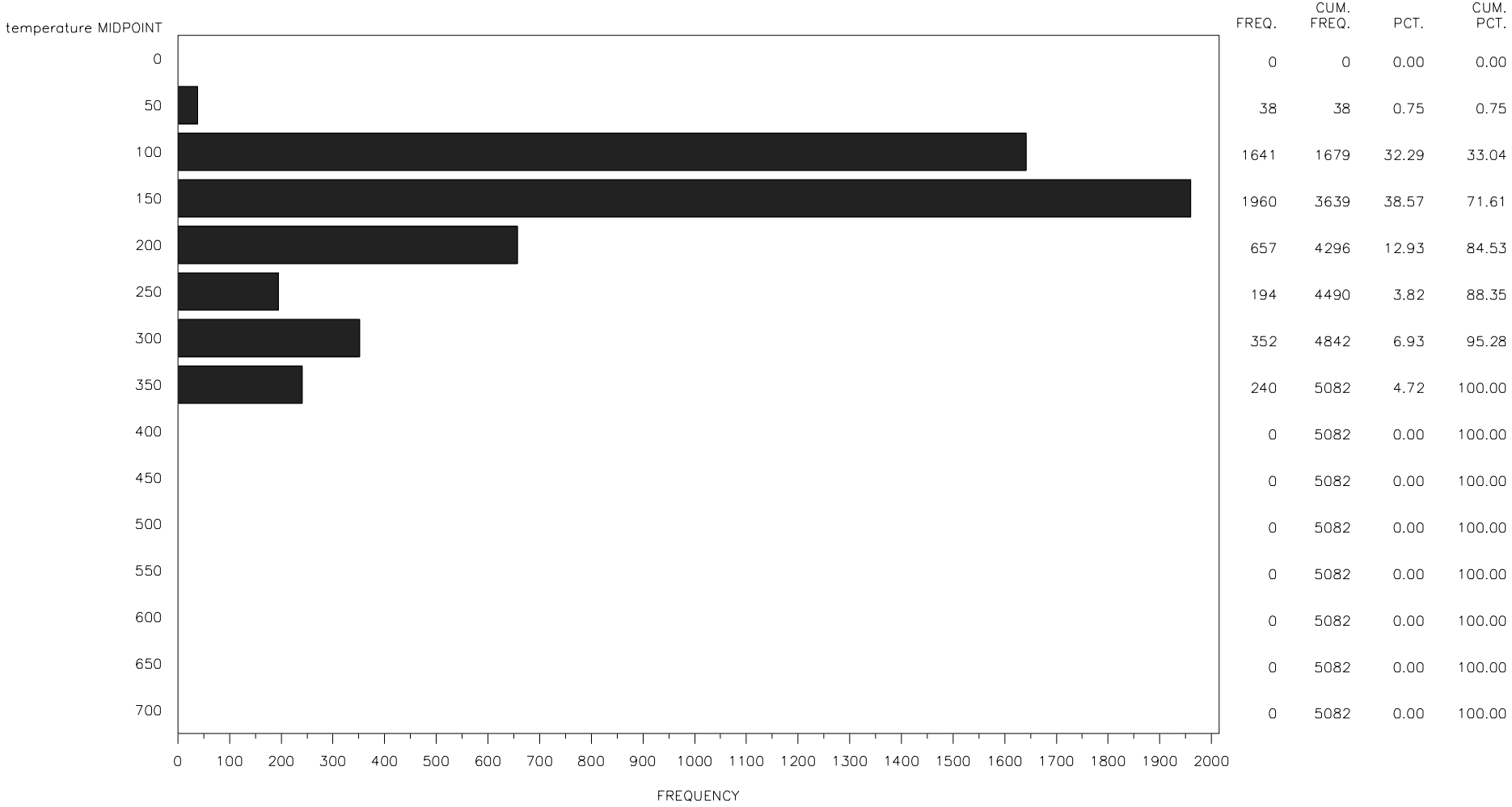
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	1	1	0.01	0.01
50	30	31	0.20	0.21
100	59	90	0.39	0.60
150	27	117	0.18	0.78
200	172	289	1.14	1.92
250	342	631	2.27	4.19
300	270	901	1.79	5.98
350	301	1202	2.00	7.98
400	563	1765	3.74	11.72
450	1587	3352	10.54	22.25
500	9698	13050	64.38	86.64
550	2013	15063	13.36	100.00
600	0	15063	0.00	100.00
650	0	15063	0.00	100.00
700	0	15063	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070826_1_Compactor_CommercialConstruction



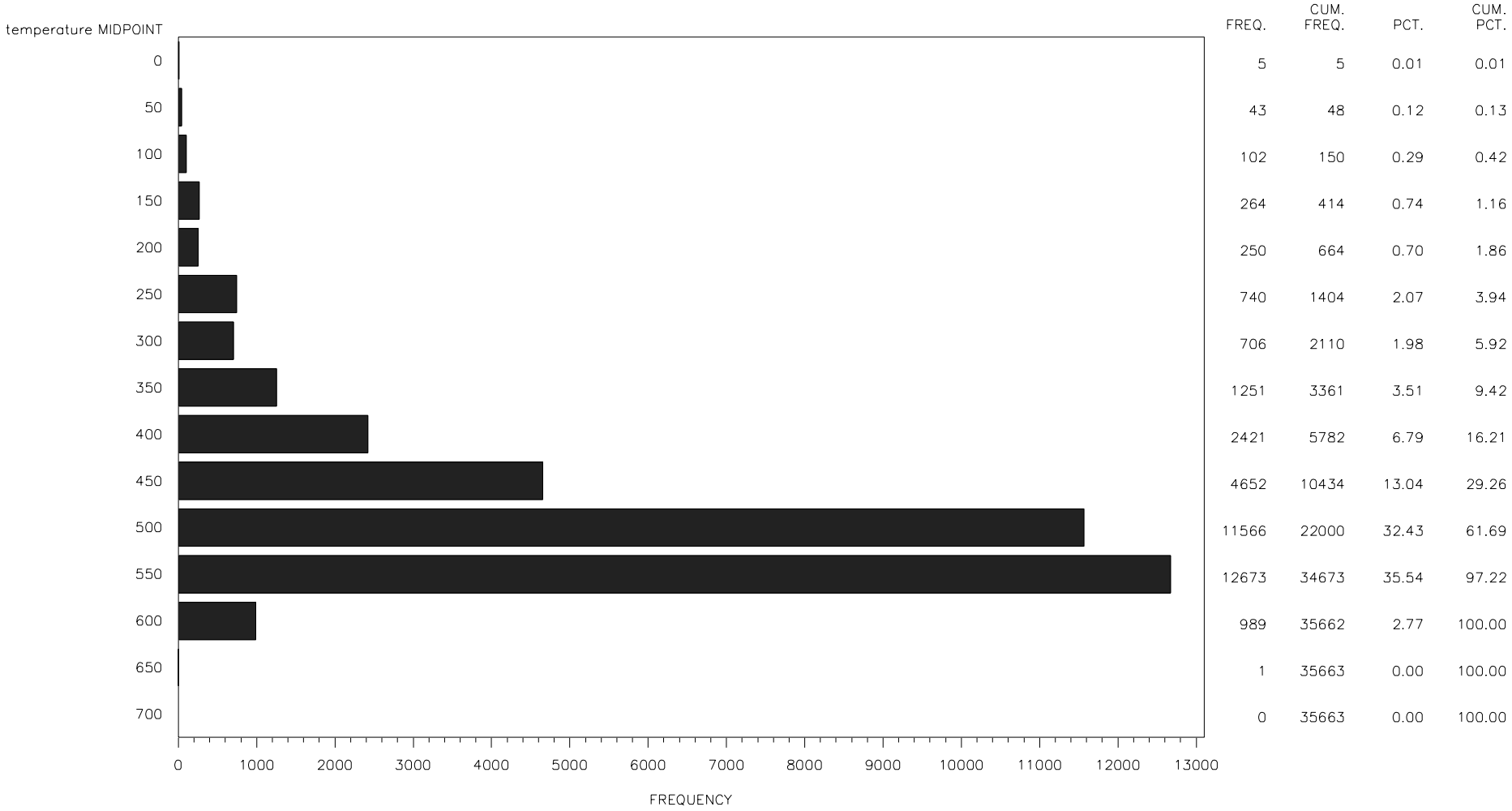
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	157	157	0.88	0.88
100	1231	1388	6.88	7.76
150	554	1942	3.10	10.86
200	888	2830	4.96	15.82
250	1411	4241	7.89	23.71
300	12130	16371	67.81	91.51
350	1518	17889	8.49	100.00
400	0	17889	0.00	100.00
450	0	17889	0.00	100.00
500	0	17889	0.00	100.00
550	0	17889	0.00	100.00
600	0	17889	0.00	100.00
650	0	17889	0.00	100.00
700	0	17889	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070830_1_Backhoe_PublicWorks



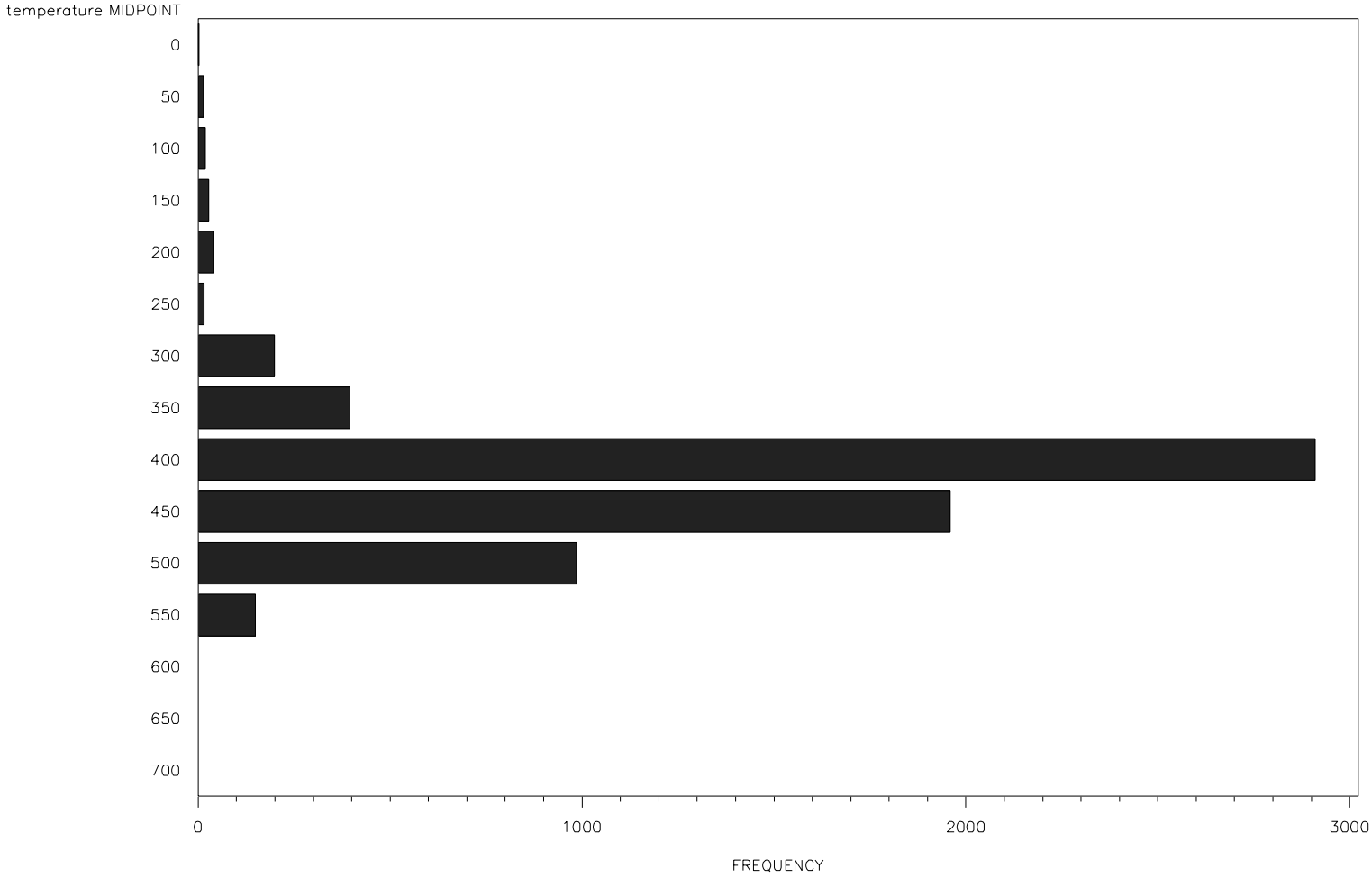
	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	38	38	0.75	0.75
100	1641	1679	32.29	33.04
150	1960	3639	38.57	71.61
200	657	4296	12.93	84.53
250	194	4490	3.82	88.35
300	352	4842	6.93	95.28
350	240	5082	4.72	100.00
400	0	5082	0.00	100.00
450	0	5082	0.00	100.00
500	0	5082	0.00	100.00
550	0	5082	0.00	100.00
600	0	5082	0.00	100.00
650	0	5082	0.00	100.00
700	0	5082	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070831_1_4WDTractorRootPlow_WasteWaterTreatment



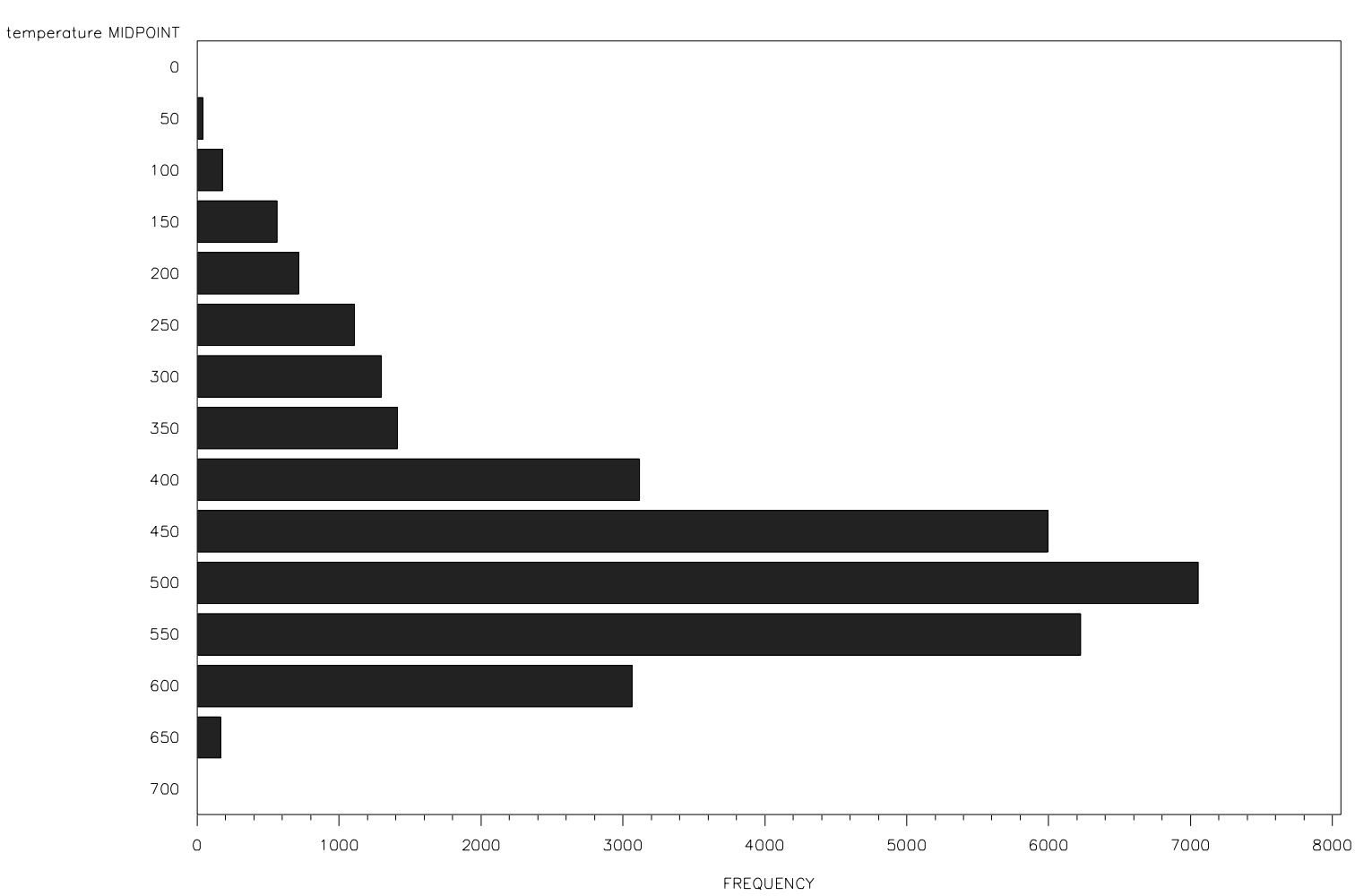
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	5	5	0.01	0.01
50	43	48	0.12	0.13
100	102	150	0.29	0.42
150	264	414	0.74	1.16
200	250	664	0.70	1.86
250	740	1404	2.07	3.94
300	706	2110	1.98	5.92
350	1251	3361	3.51	9.42
400	2421	5782	6.79	16.21
450	4652	10434	13.04	29.26
500	11566	22000	32.43	61.69
550	12673	34673	35.54	97.22
600	989	35662	2.77	100.00
650	1	35663	0.00	100.00
700	0	35663	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070831__2_WheelLoader_Landfill



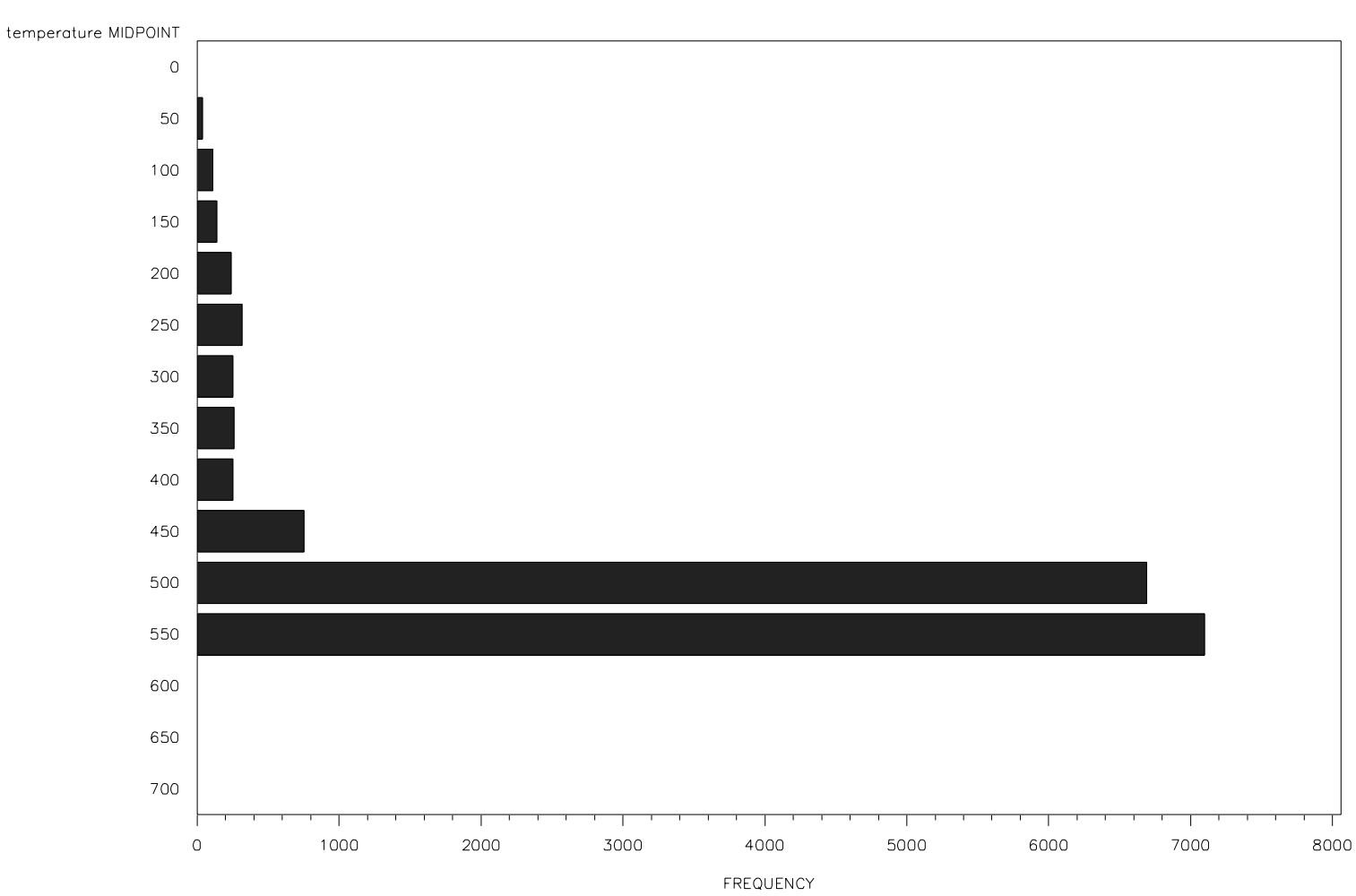
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	2	2	0.03	0.03
50	13	15	0.19	0.22
100	18	33	0.27	0.49
150	28	61	0.42	0.91
200	40	101	0.60	1.50
250	15	116	0.22	1.73
300	198	314	2.95	4.68
350	396	710	5.90	10.58
400	2909	3619	43.33	53.91
450	1959	5578	29.18	83.09
500	986	6564	14.69	97.78
550	149	6713	2.22	100.00
600	0	6713	0.00	100.00
650	0	6713	0.00	100.00
700	0	6713	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070831_3_Scraper_KieferLandfill



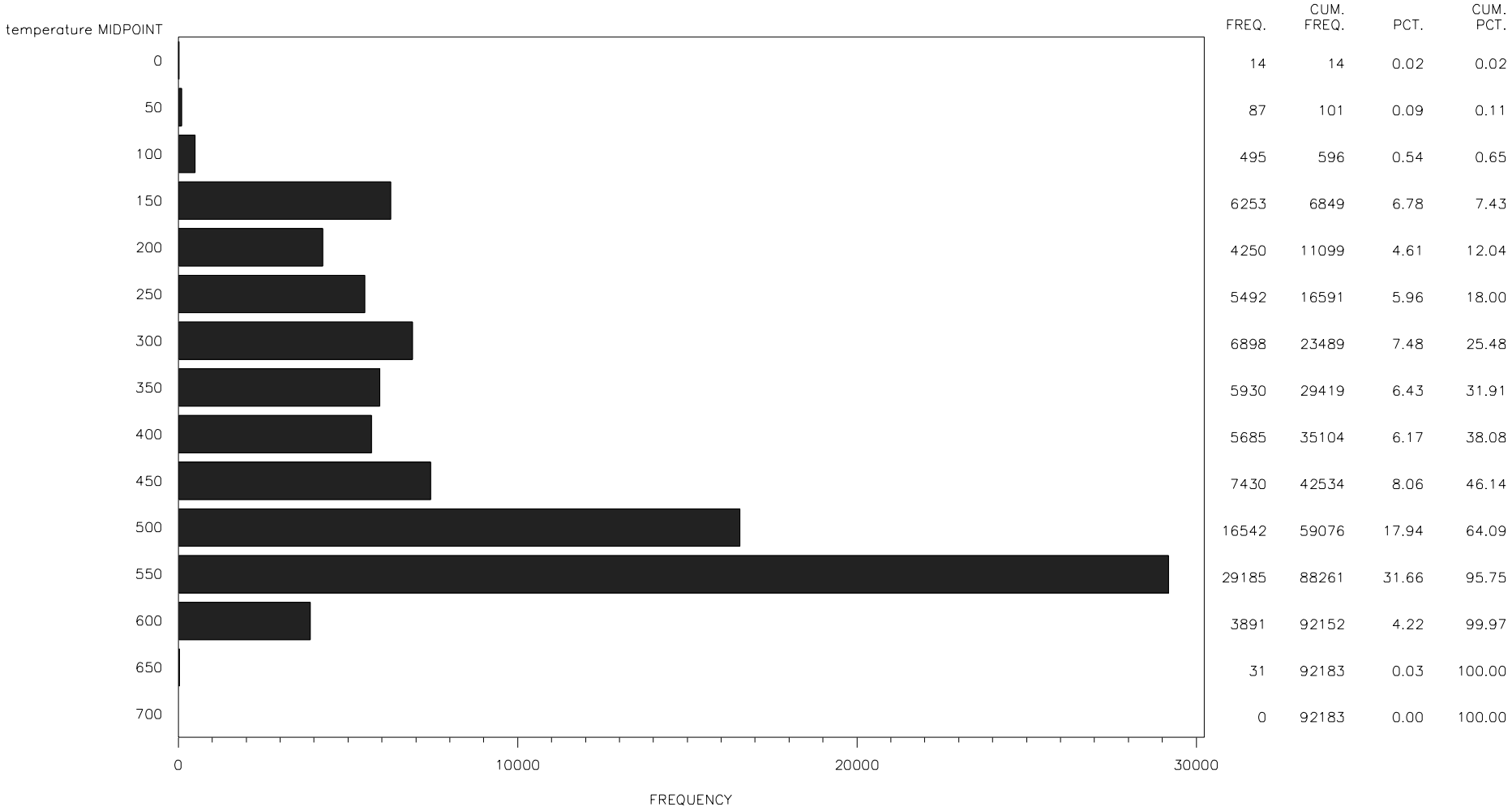
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	41	41	0.13	0.13
100	178	219	0.58	0.71
150	561	780	1.81	2.52
200	715	1495	2.31	4.83
250	1109	2604	3.58	8.42
300	1299	3903	4.20	12.62
350	1413	5316	4.57	17.18
400	3118	8434	10.08	27.26
450	5993	14427	19.37	46.64
500	7055	21482	22.81	69.44
550	6223	27705	20.12	89.56
600	3064	30769	9.90	99.46
650	166	30935	0.54	100.00
700	0	30935	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070831_4_Dozer_KieferLandfill



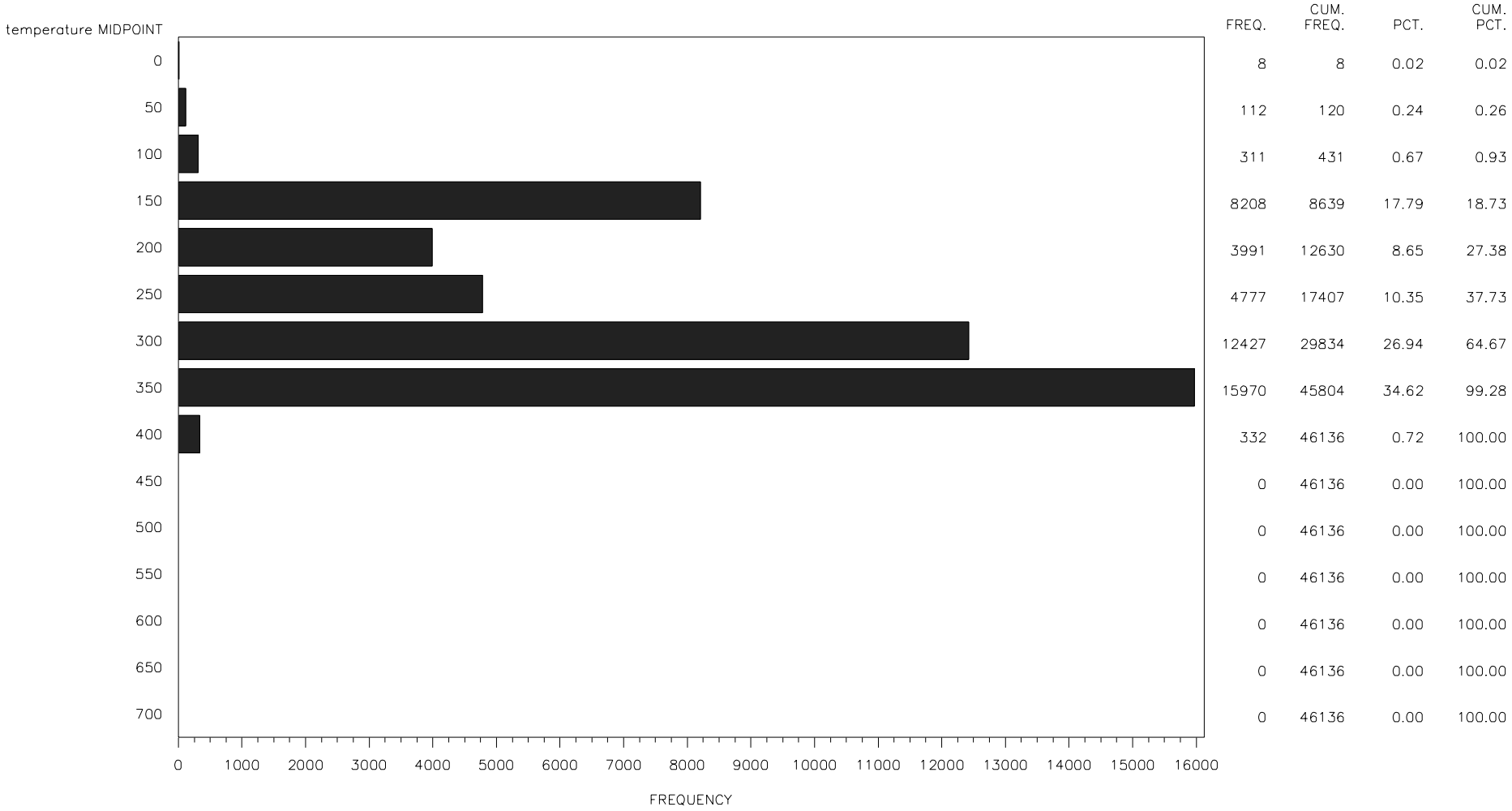
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	37	37	0.23	0.23
100	109	146	0.68	0.90
150	139	285	0.86	1.77
200	240	525	1.49	3.25
250	314	839	1.94	5.20
300	251	1090	1.55	6.75
350	261	1351	1.62	8.37
400	253	1604	1.57	9.93
450	754	2358	4.67	14.61
500	6689	9047	41.43	56.04
550	7098	16145	43.96	100.00
600	0	16145	0.00	100.00
650	0	16145	0.00	100.00
700	0	16145	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070906_1_Excavator_ResidentialConstruction



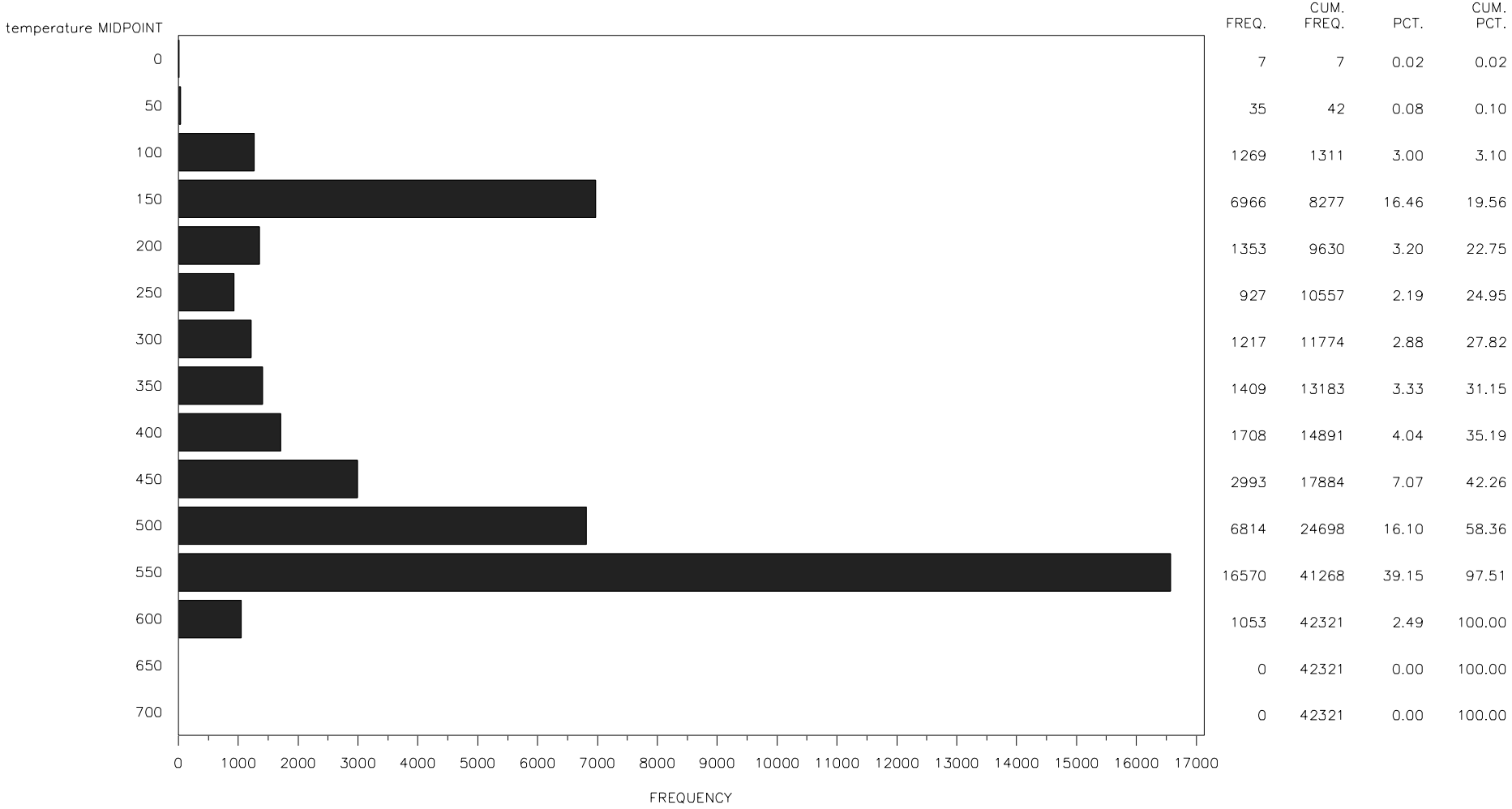
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	14	14	0.02	0.02
50	87	101	0.09	0.11
100	495	596	0.54	0.65
150	6253	6849	6.78	7.43
200	4250	11099	4.61	12.04
250	5492	16591	5.96	18.00
300	6898	23489	7.48	25.48
350	5930	29419	6.43	31.91
400	5685	35104	6.17	38.08
450	7430	42534	8.06	46.14
500	16542	59076	17.94	64.09
550	29185	88261	31.66	95.75
600	3891	92152	4.22	99.97
650	31	92183	0.03	100.00
700	0	92183	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070907_1_ClawTractor/Loader_YardWaste



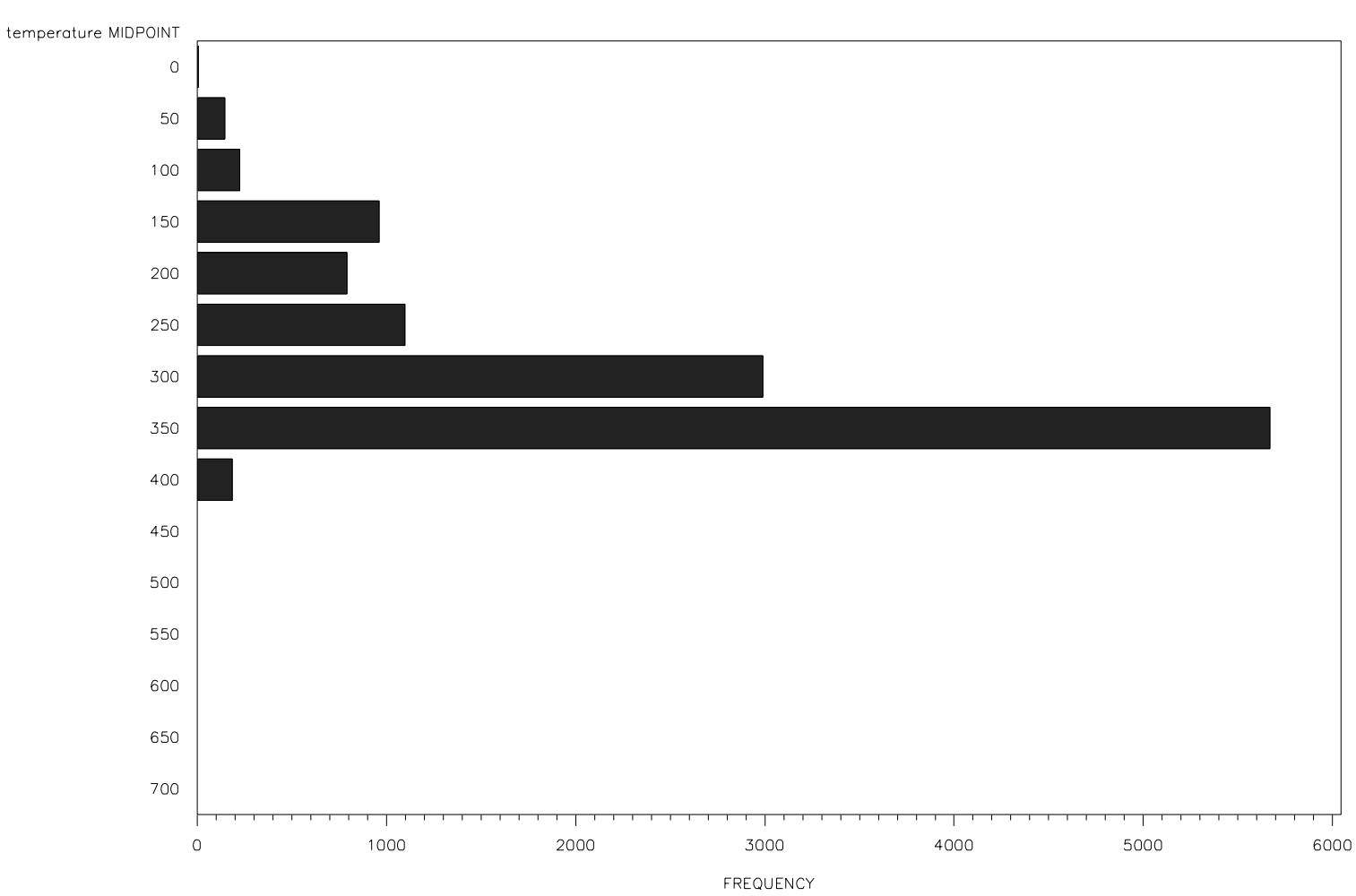
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	8	8	0.02	0.02
50	112	120	0.24	0.26
100	311	431	0.67	0.93
150	8208	8639	17.79	18.73
200	3991	12630	8.65	27.38
250	4777	17407	10.35	37.73
300	12427	29834	26.94	64.67
350	15970	45804	34.62	99.28
400	332	46136	0.72	100.00
450	0	46136	0.00	100.00
500	0	46136	0.00	100.00
550	0	46136	0.00	100.00
600	0	46136	0.00	100.00
650	0	46136	0.00	100.00
700	0	46136	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070913_1_Excavator_KieferLandfill



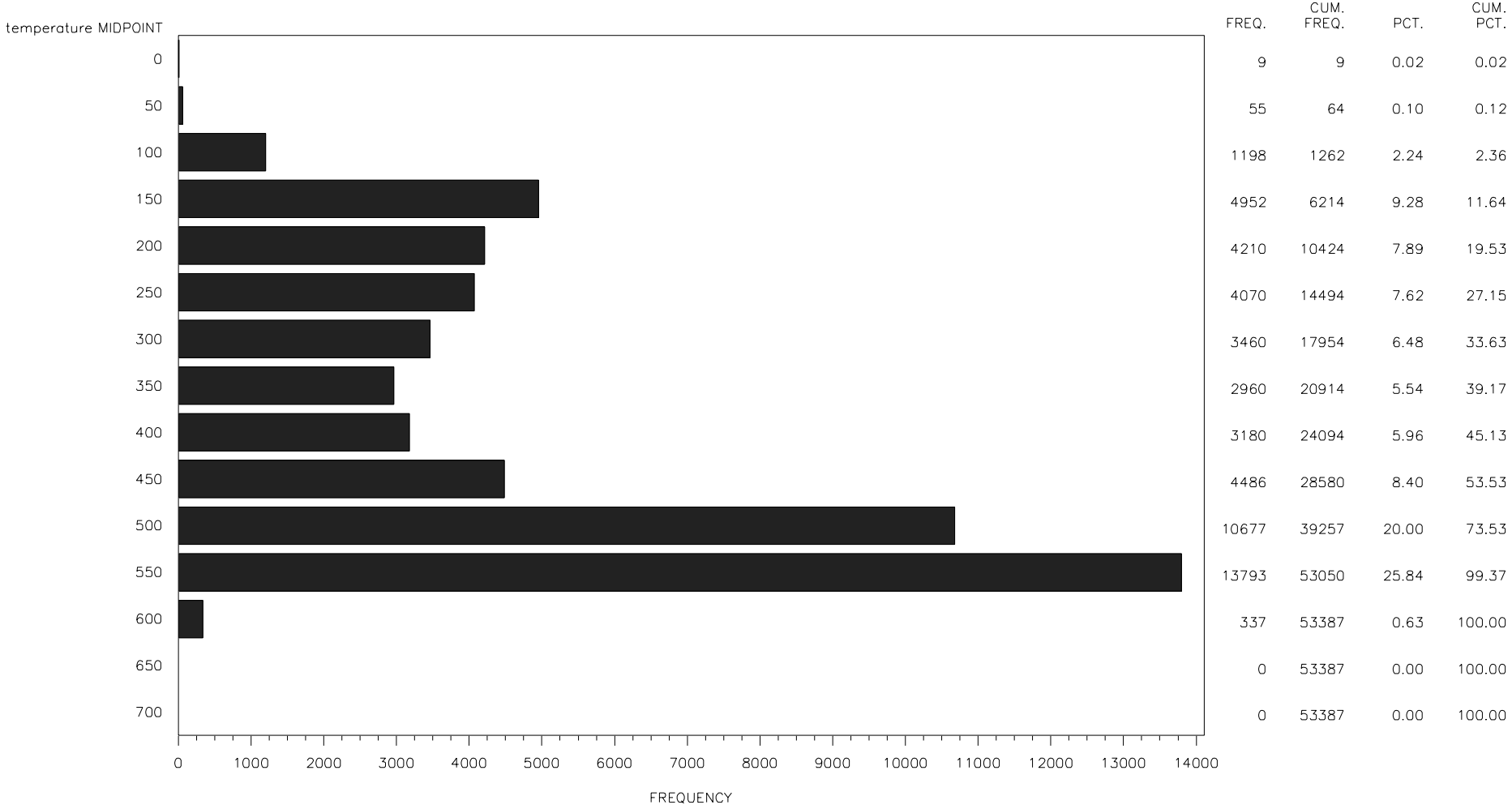
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	7	7	0.02	0.02
50	35	42	0.08	0.10
100	1269	1311	3.00	3.10
150	6966	8277	16.46	19.56
200	1353	9630	3.20	22.75
250	927	10557	2.19	24.95
300	1217	11774	2.88	27.82
350	1409	13183	3.33	31.15
400	1708	14891	4.04	35.19
450	2993	17884	7.07	42.26
500	6814	24698	16.10	58.36
550	16570	41268	39.15	97.51
600	1053	42321	2.49	100.00
650	0	42321	0.00	100.00
700	0	42321	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070917_1_ClawTractor/Loader_YardWaste



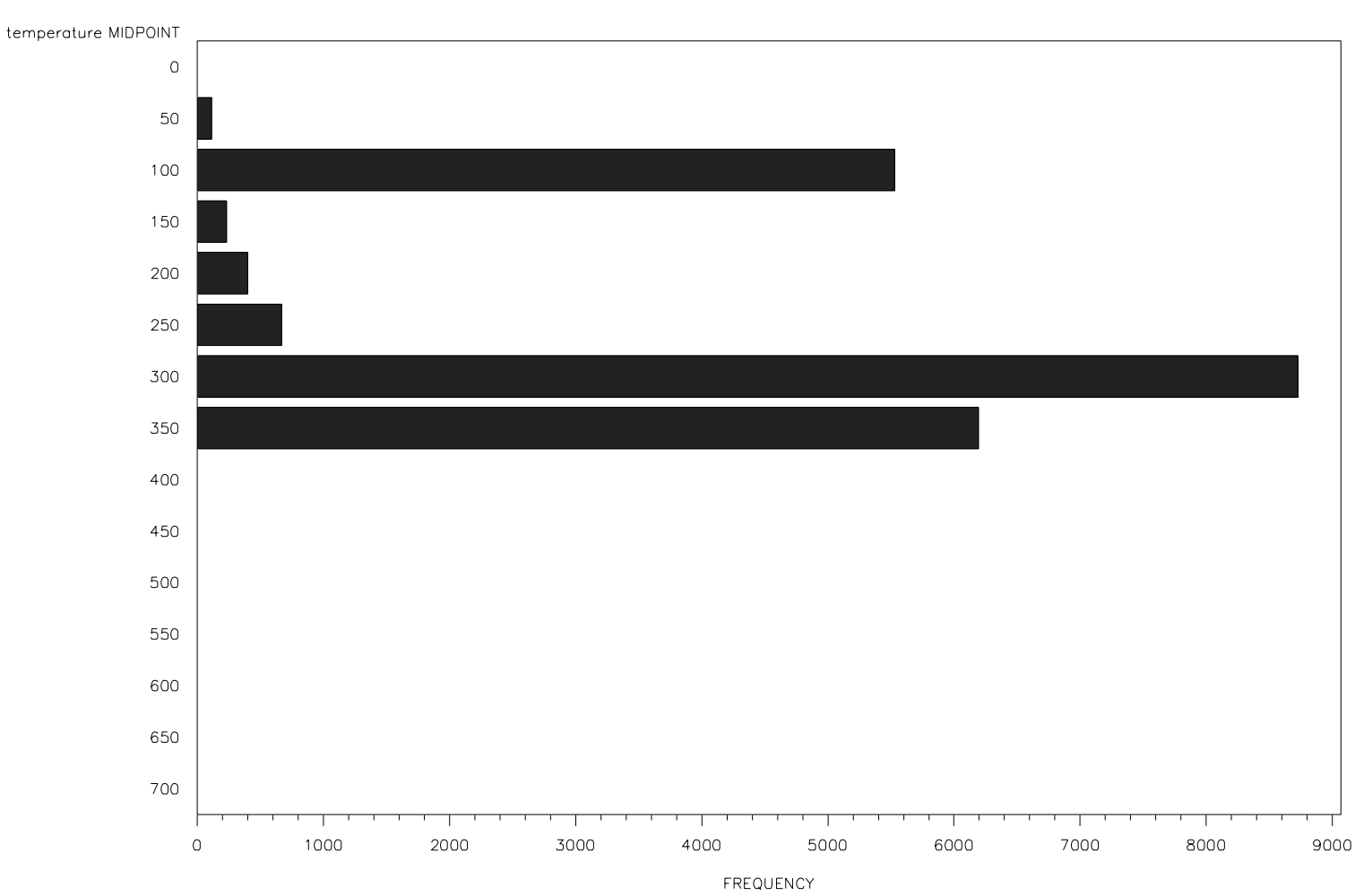
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	8	8	0.07	0.07
50	146	154	1.21	1.28
100	225	379	1.86	3.14
150	962	1341	7.97	11.11
200	791	2132	6.55	17.66
250	1097	3229	9.09	26.75
300	2989	6218	24.76	51.51
350	5669	11887	46.96	98.48
400	184	12071	1.52	100.00
450	0	12071	0.00	100.00
500	0	12071	0.00	100.00
550	0	12071	0.00	100.00
600	0	12071	0.00	100.00
650	0	12071	0.00	100.00
700	0	12071	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070919_1_Excavator_CommercialConstruction



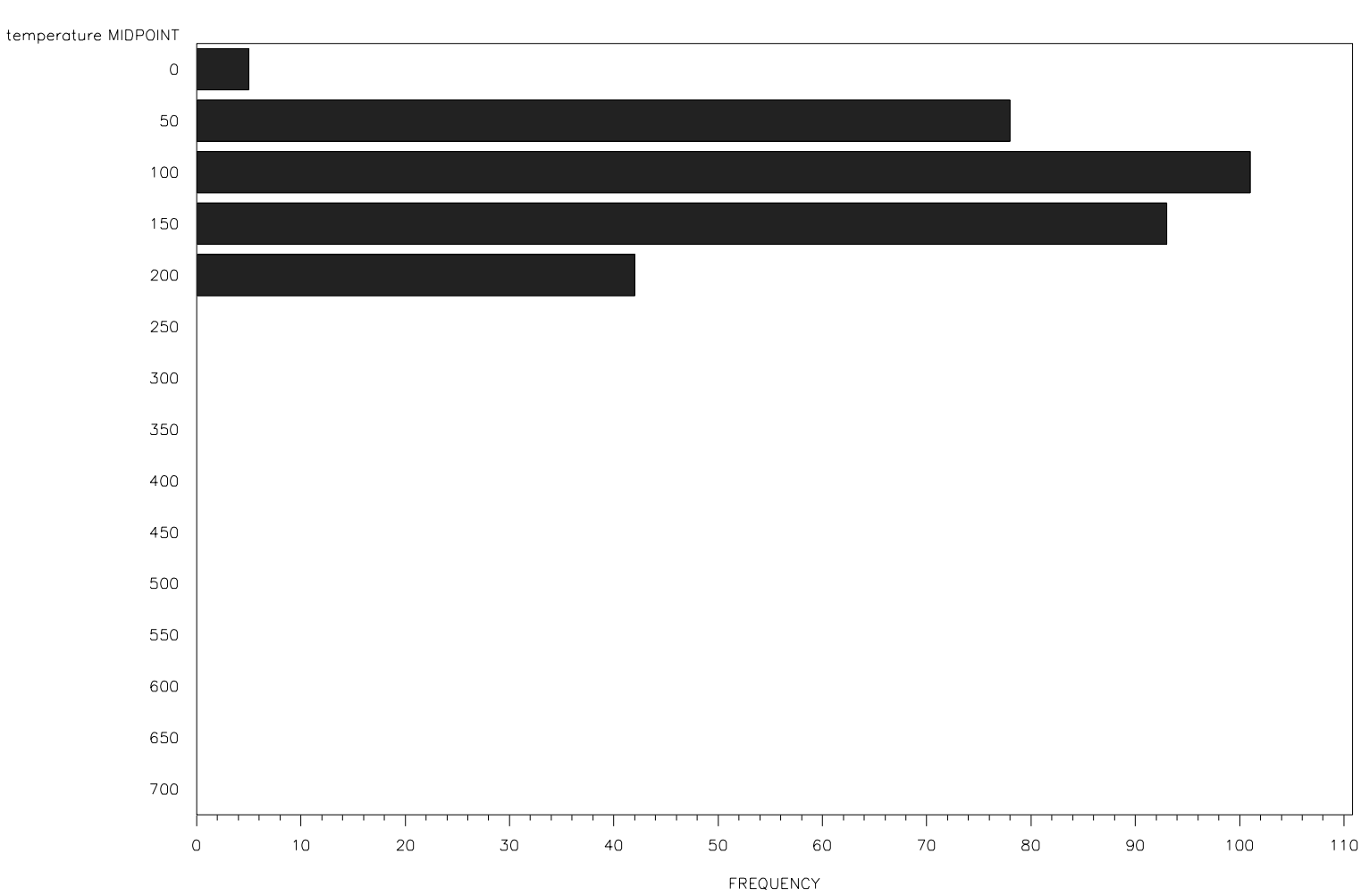
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	9	9	0.02	0.02
50	55	64	0.10	0.12
100	1198	1262	2.24	2.36
150	4952	6214	9.28	11.64
200	4210	10424	7.89	19.53
250	4070	14494	7.62	27.15
300	3460	17954	6.48	33.63
350	2960	20914	5.54	39.17
400	3180	24094	5.96	45.13
450	4486	28580	8.40	53.53
500	10677	39257	20.00	73.53
550	13793	53050	25.84	99.37
600	337	53387	0.63	100.00
650	0	53387	0.00	100.00
700	0	53387	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070923_1_Compactor_CommercialConstruction



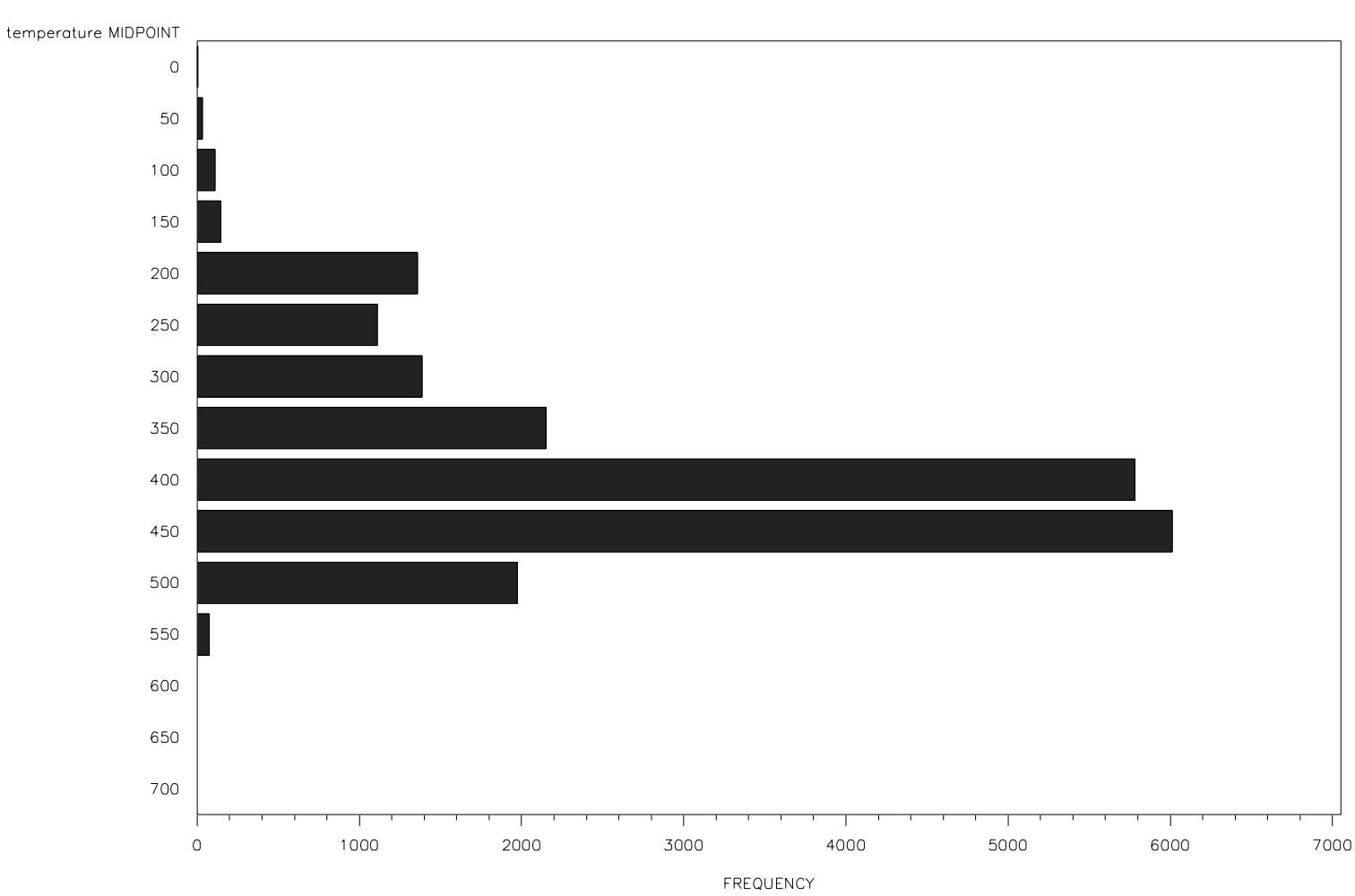
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	113	113	0.52	0.52
100	5528	5641	25.29	25.80
150	231	5872	1.06	26.86
200	401	6273	1.83	28.69
250	670	6943	3.06	31.76
300	8727	15670	39.92	71.68
350	6191	21861	28.32	100.00
400	0	21861	0.00	100.00
450	0	21861	0.00	100.00
500	0	21861	0.00	100.00
550	0	21861	0.00	100.00
600	0	21861	0.00	100.00
650	0	21861	0.00	100.00
700	0	21861	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070926_1_ClawTractor/Loader_YardWaste



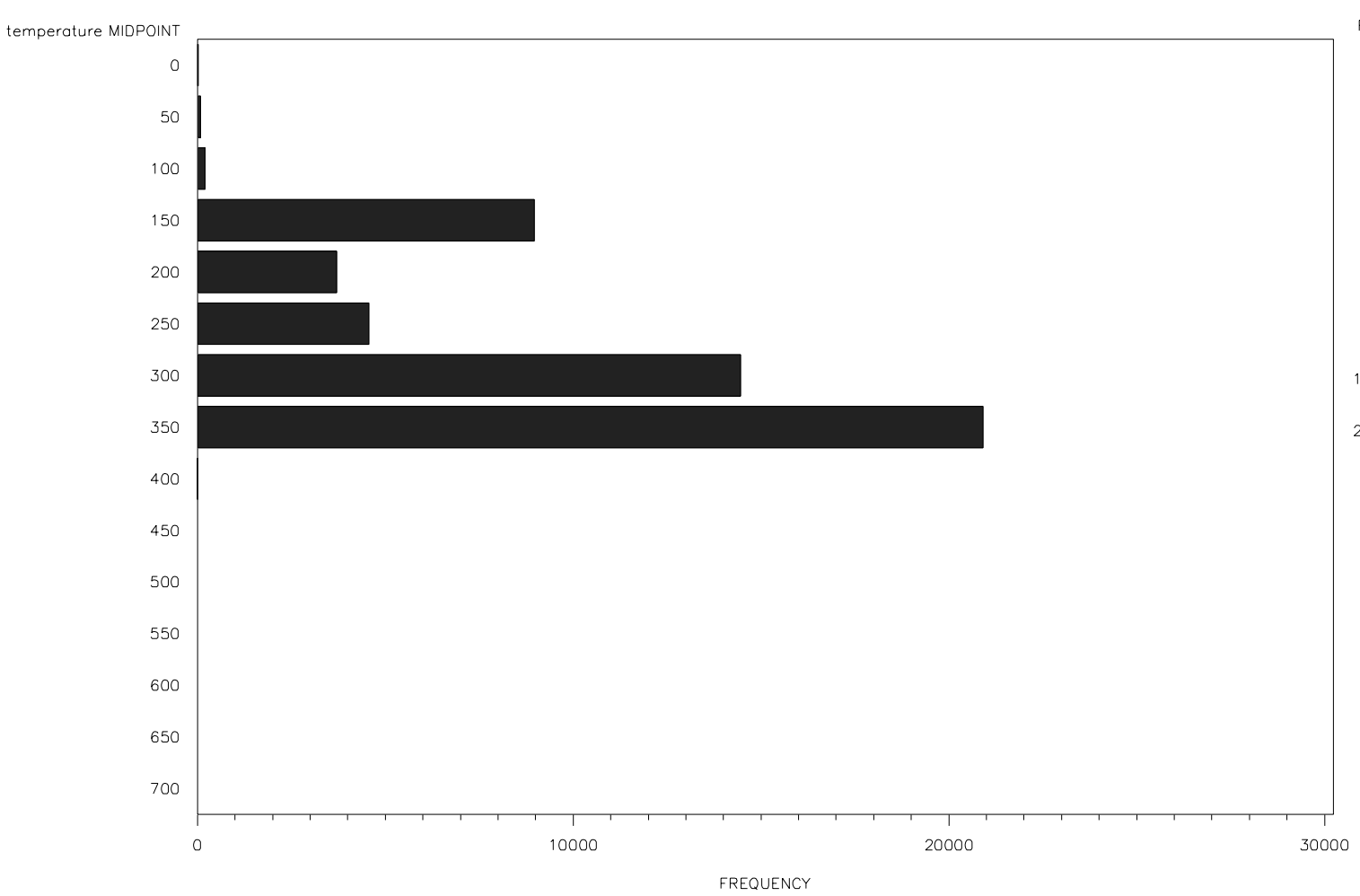
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	5	5	1.57	1.57
50	78	83	24.45	26.02
100	101	184	31.66	57.68
150	93	277	29.15	86.83
200	42	319	13.17	100.00
250	0	319	0.00	100.00
300	0	319	0.00	100.00
350	0	319	0.00	100.00
400	0	319	0.00	100.00
450	0	319	0.00	100.00
500	0	319	0.00	100.00
550	0	319	0.00	100.00
600	0	319	0.00	100.00
650	0	319	0.00	100.00
700	0	319	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20070930_1_WheelLoader_WasteWaterTreatment



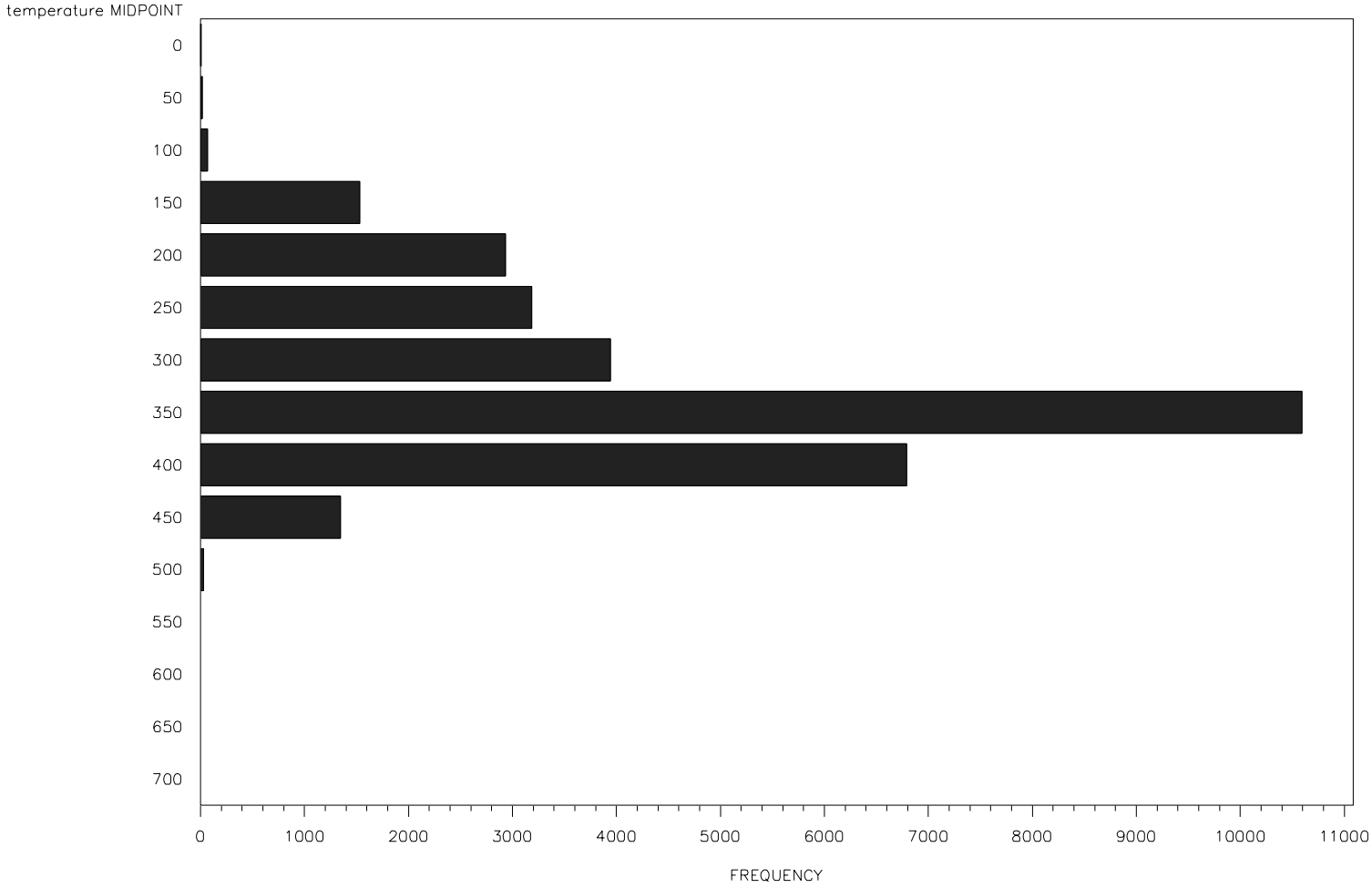
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	4	4	0.02	0.02
50	32	36	0.16	0.18
100	110	146	0.55	0.72
150	146	292	0.72	1.45
200	1360	1652	6.75	8.20
250	1112	2764	5.52	13.72
300	1386	4150	6.88	20.60
350	2152	6302	10.68	31.28
400	5782	12084	28.70	59.98
450	6014	18098	29.85	89.83
500	1974	20072	9.80	99.62
550	76	20148	0.38	100.00
600	0	20148	0.00	100.00
650	0	20148	0.00	100.00
700	0	20148	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20071004_1_ClawTractor/Loader_YardWaste



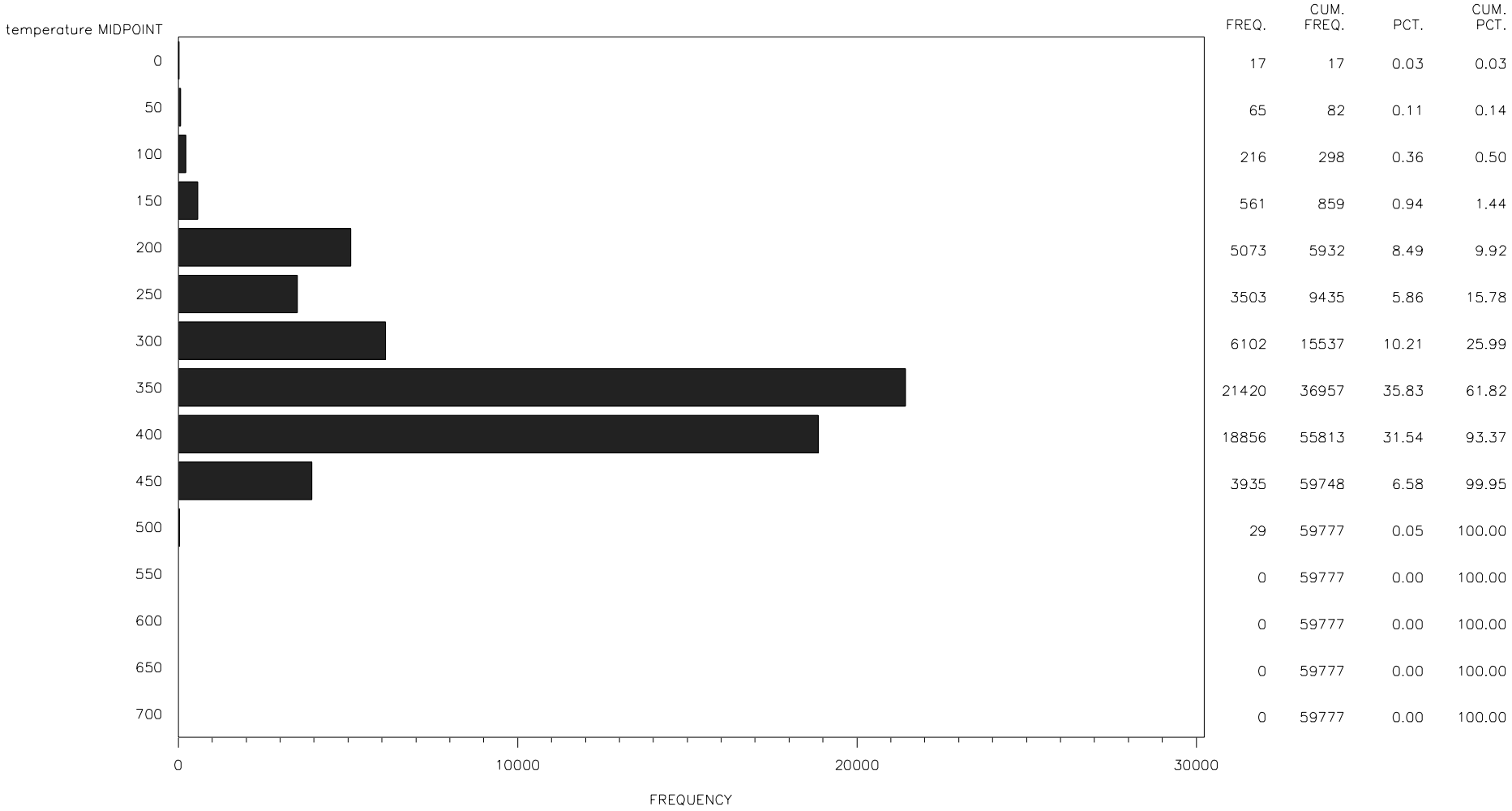
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	11	11	0.02	0.02
50	86	97	0.16	0.18
100	200	297	0.38	0.56
150	8961	9258	16.95	17.51
200	3702	12960	7.00	24.51
250	4552	17512	8.61	33.12
300	14459	31971	27.34	60.46
350	20906	52877	39.54	100.00
400	2	52879	0.00	100.00
450	0	52879	0.00	100.00
500	0	52879	0.00	100.00
550	0	52879	0.00	100.00
600	0	52879	0.00	100.00
650	0	52879	0.00	100.00
700	0	52879	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20071010_1_RubberWheelLoader_KieferLandfill



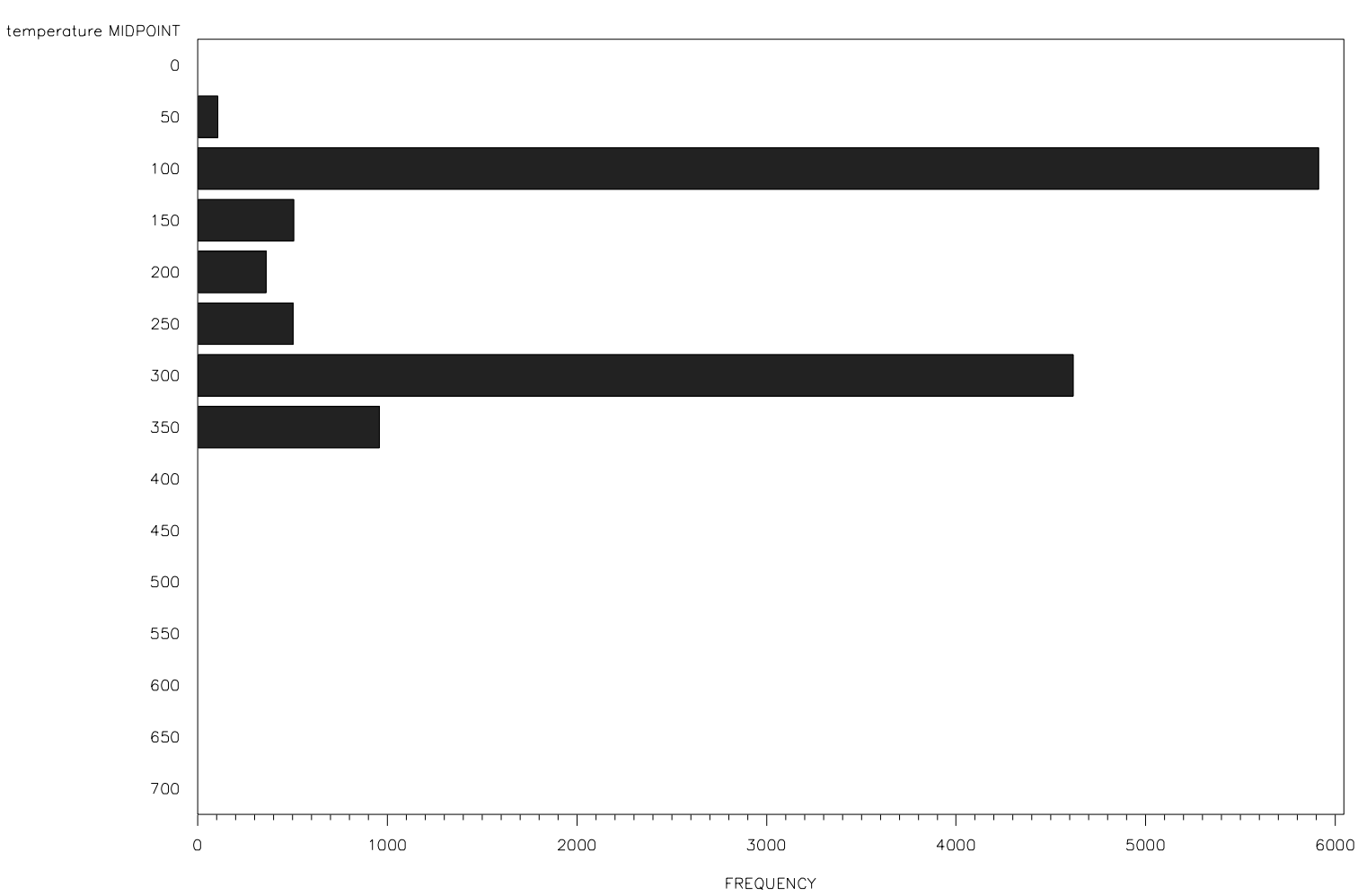
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	4	4	0.01	0.01
50	19	23	0.06	0.08
100	70	93	0.23	0.31
150	1531	1624	5.03	5.33
200	2933	4557	9.63	14.97
250	3188	7745	10.47	25.44
300	3945	11690	12.96	38.39
350	10591	22281	34.78	73.17
400	6790	29071	22.30	95.47
450	1348	30419	4.43	99.90
500	30	30449	0.10	100.00
550	0	30449	0.00	100.00
600	0	30449	0.00	100.00
650	0	30449	0.00	100.00
700	0	30449	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20071018_1_RubberWheelLoader_CommercialConstruction



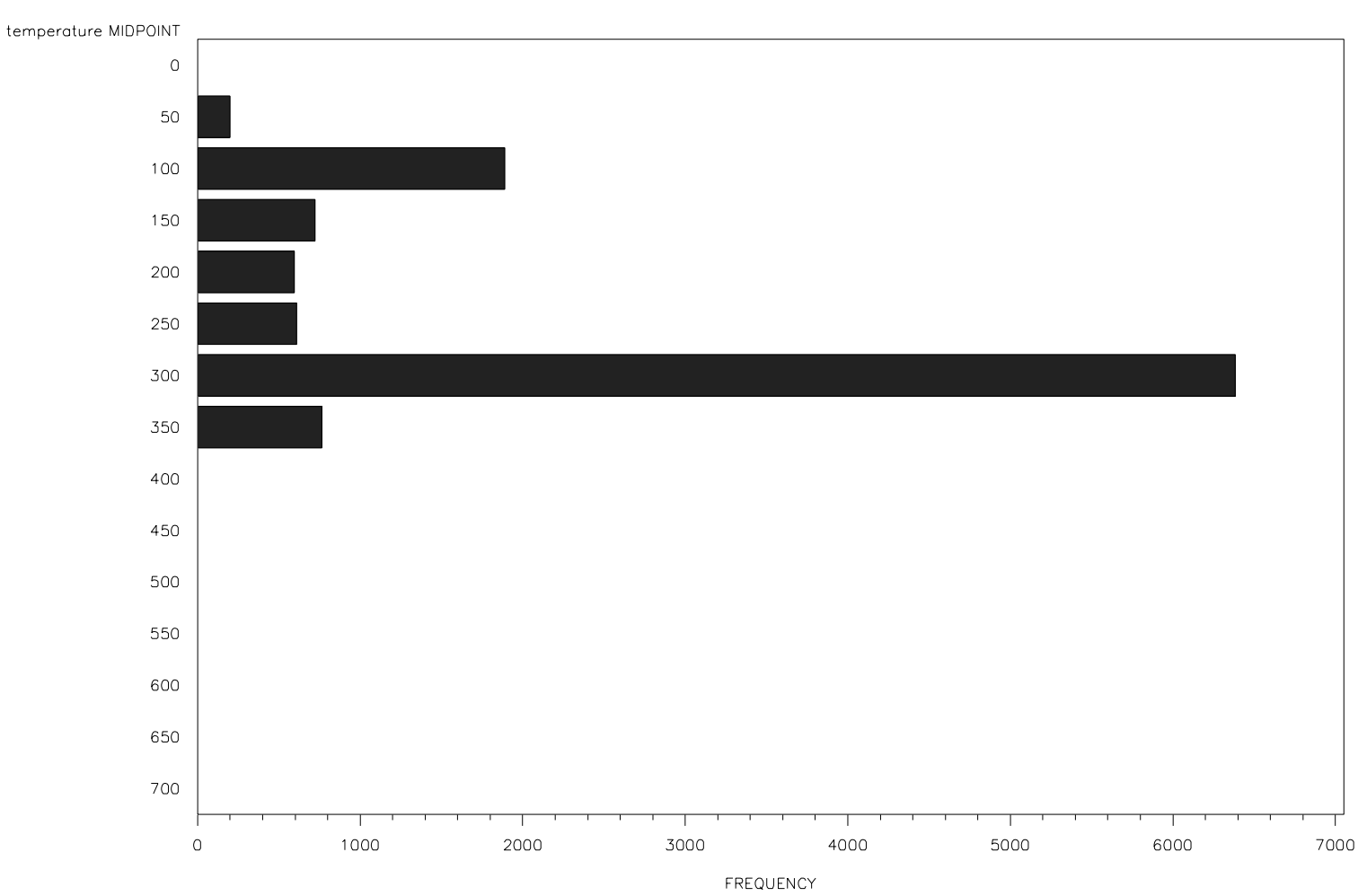
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	17	17	0.03	0.03
50	65	82	0.11	0.14
100	216	298	0.36	0.50
150	561	859	0.94	1.44
200	5073	5932	8.49	9.92
250	3503	9435	5.86	15.78
300	6102	15537	10.21	25.99
350	21420	36957	35.83	61.82
400	18856	55813	31.54	93.37
450	3935	59748	6.58	99.95
500	29	59777	0.05	100.00
550	0	59777	0.00	100.00
600	0	59777	0.00	100.00
650	0	59777	0.00	100.00
700	0	59777	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20071025_1_Compactor_CommercialConstruction



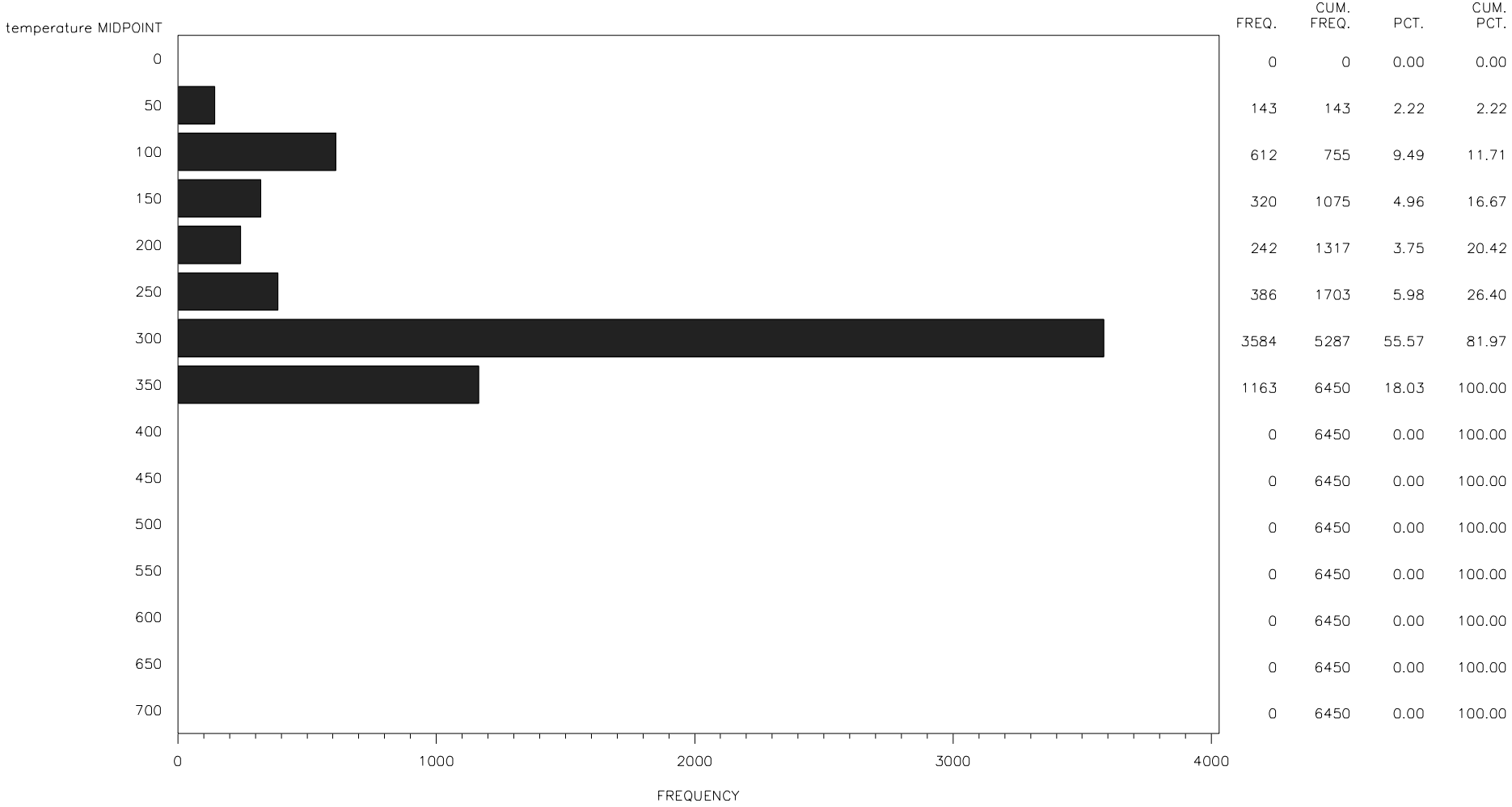
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	108	108	0.83	0.83
100	5911	6019	45.59	46.42
150	506	6525	3.90	50.32
200	361	6886	2.78	53.11
250	504	7390	3.89	57.00
300	4617	12007	35.61	92.60
350	959	12966	7.40	100.00
400	0	12966	0.00	100.00
450	0	12966	0.00	100.00
500	0	12966	0.00	100.00
550	0	12966	0.00	100.00
600	0	12966	0.00	100.00
650	0	12966	0.00	100.00
700	0	12966	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20071101_1_Compactor_CommercialConstruction



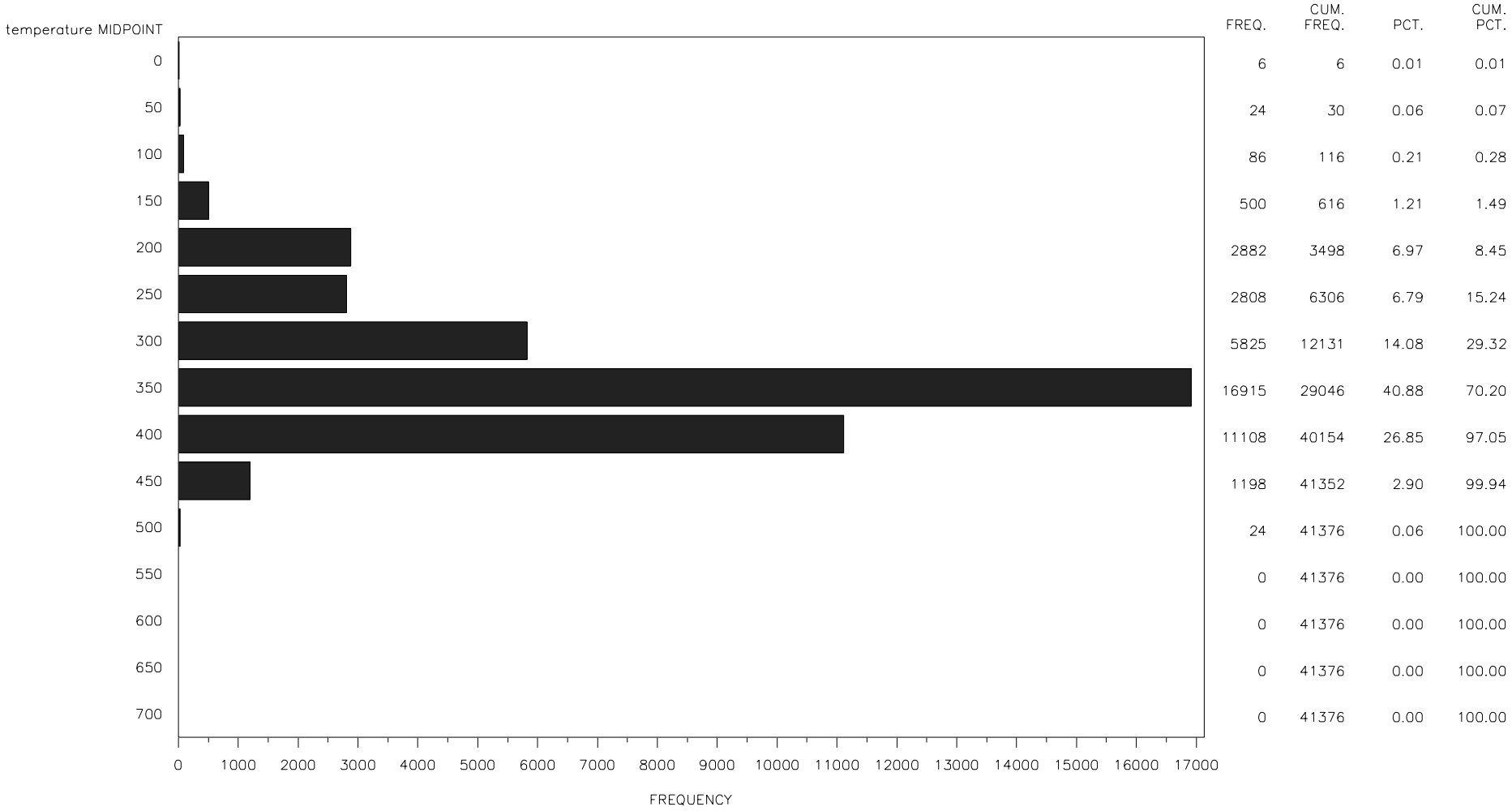
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	199	199	1.78	1.78
100	1890	2089	16.93	18.71
150	721	2810	6.46	25.17
200	596	3406	5.34	30.51
250	609	4015	5.46	35.96
300	6385	10400	57.19	93.16
350	764	11164	6.84	100.00
400	0	11164	0.00	100.00
450	0	11164	0.00	100.00
500	0	11164	0.00	100.00
550	0	11164	0.00	100.00
600	0	11164	0.00	100.00
650	0	11164	0.00	100.00
700	0	11164	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20071108_1_Compactor_KieferLandfill



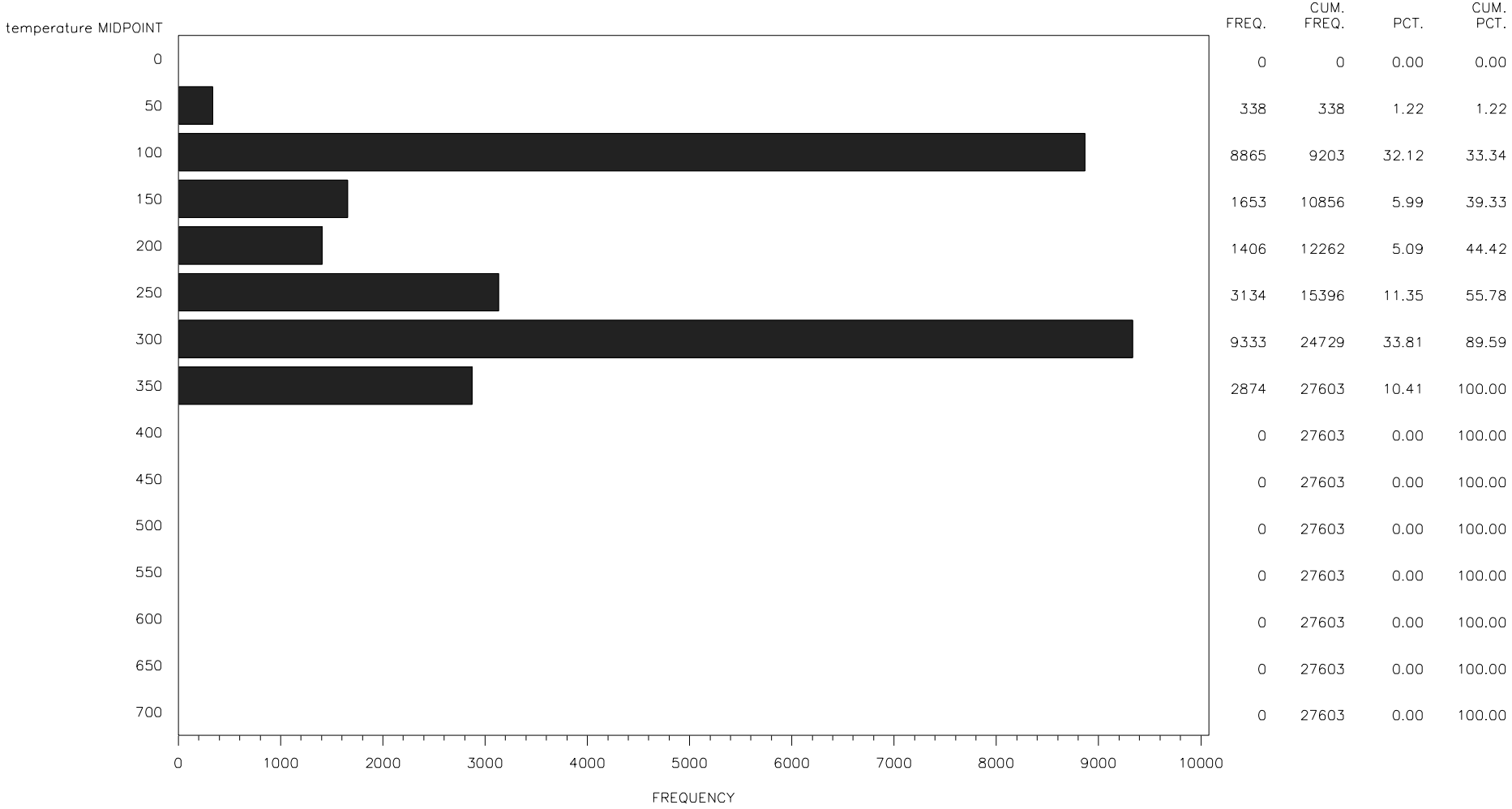
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	143	143	2.22	2.22
100	612	755	9.49	11.71
150	320	1075	4.96	16.67
200	242	1317	3.75	20.42
250	386	1703	5.98	26.40
300	3584	5287	55.57	81.97
350	1163	6450	18.03	100.00
400	0	6450	0.00	100.00
450	0	6450	0.00	100.00
500	0	6450	0.00	100.00
550	0	6450	0.00	100.00
600	0	6450	0.00	100.00
650	0	6450	0.00	100.00
700	0	6450	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20071112_1_RubberWheelLoader_KieferLandfill



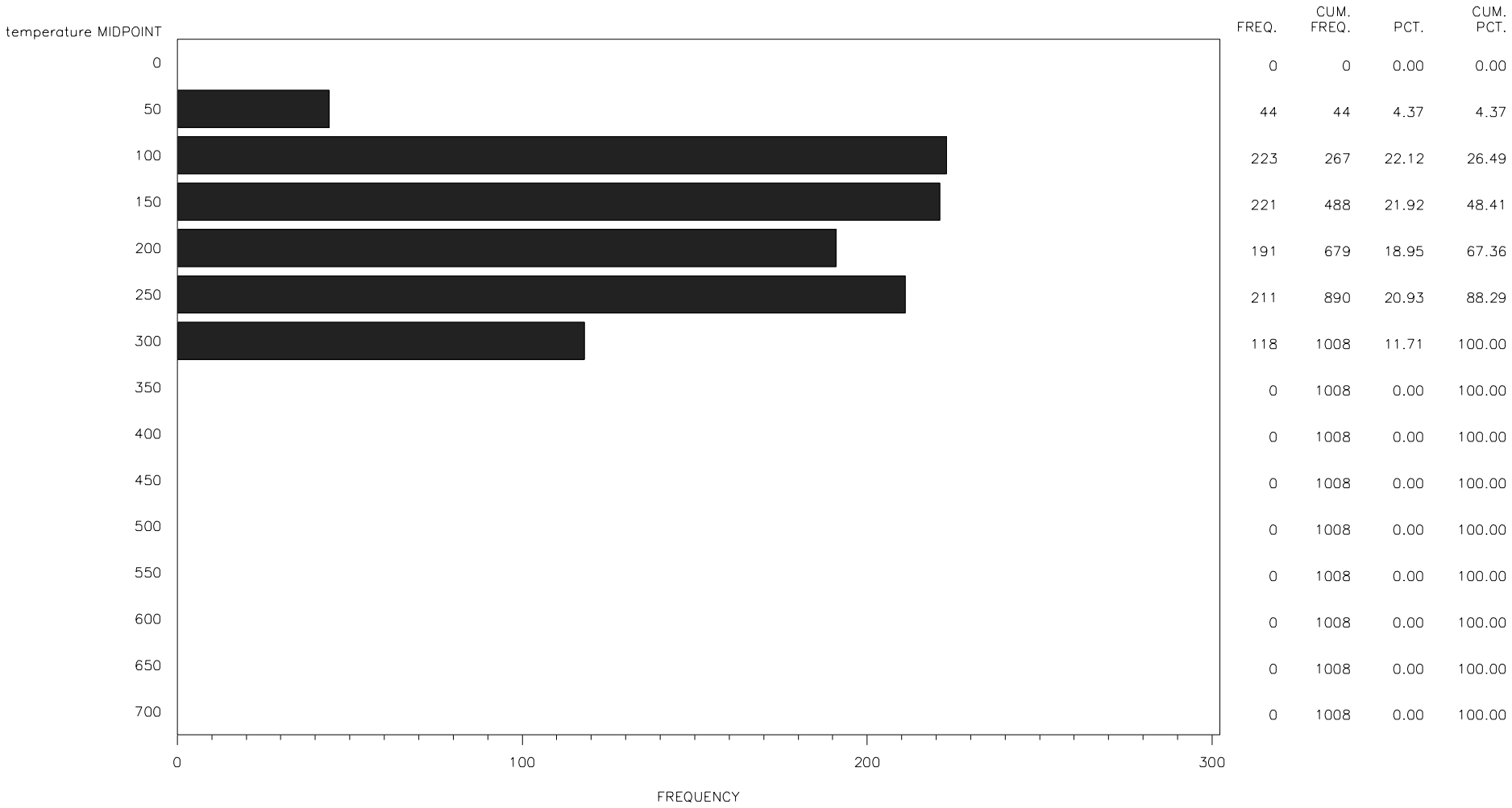
temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	6	6	0.01	0.01
50	24	30	0.06	0.07
100	86	116	0.21	0.28
150	500	616	1.21	1.49
200	2882	3498	6.97	8.45
250	2808	6306	6.79	15.24
300	5825	12131	14.08	29.32
350	16915	29046	40.88	70.20
400	11108	40154	26.85	97.05
450	1198	41352	2.90	99.94
500	24	41376	0.06	100.00
550	0	41376	0.00	100.00
600	0	41376	0.00	100.00
650	0	41376	0.00	100.00
700	0	41376	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20071115_1_Compactor_CommercialConstruction



temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	338	338	1.22	1.22
100	8865	9203	32.12	33.34
150	1653	10856	5.99	39.33
200	1406	12262	5.09	44.42
250	3134	15396	11.35	55.78
300	9333	24729	33.81	89.59
350	2874	27603	10.41	100.00
400	0	27603	0.00	100.00
450	0	27603	0.00	100.00
500	0	27603	0.00	100.00
550	0	27603	0.00	100.00
600	0	27603	0.00	100.00
650	0	27603	0.00	100.00
700	0	27603	0.00	100.00

Exhaust Gas Temperature
plotinfo=s20071124_1_Compactor_CommercialConstruction



temperature MIDPOINT	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0	0.00	0.00
50	44	44	4.37	4.37
100	223	267	22.12	26.49
150	221	488	21.92	48.41
200	191	679	18.95	67.36
250	211	890	20.93	88.29
300	118	1008	11.71	100.00
350	0	1008	0.00	100.00
400	0	1008	0.00	100.00
450	0	1008	0.00	100.00
500	0	1008	0.00	100.00
550	0	1008	0.00	100.00
600	0	1008	0.00	100.00
650	0	1008	0.00	100.00
700	0	1008	0.00	100.00